

# Corrosion



# CORROSION COSTS INDUSTRY \$6,000,000,000.00 ANNUALLY!

**How much do you pay?**

FOLLOW THE LINE OF *most* RESISTANCE



**A SYSTEM OF SURFACE PROTECTION**

## **Don't risk needless waste**

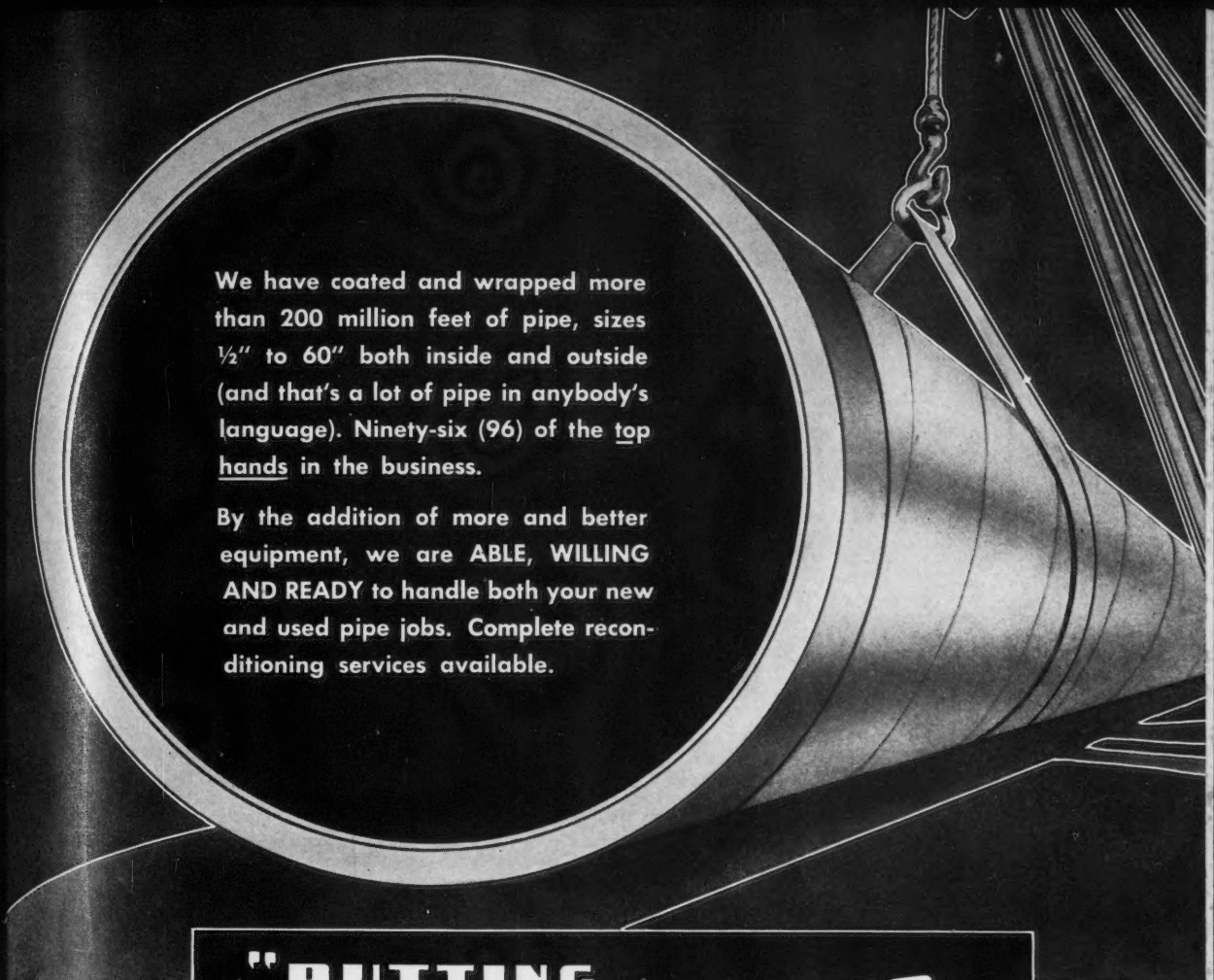
If all corrosion were as obvious as it is in steel pipe, industry would do more about it. But it is not. Often hidden or unnoticed — indoors and outdoors, above ground and below ground — corrosion takes its daily toll. Acids, alkalis, salts, gases and atmospheric conditions all are contributing factors. As a result, industry pays a terrific bill for corrosion — far more than it should. Your own cost, too, may be greater than necessary. Minimize your risk — do these two things now —

1. Check up on your costs;
2. Provide adequate protection for danger points.

Experienced and competent AMERCOAT engineers are available to help you on both. They'll check up on your costs, which may be greater than you know because the effects of corrosion are often hidden. They'll report on conditions as they find them. They'll recommend steps to take if greater protection can be provided and money saved. Inquiries from interested executives will receive prompt attention. There's no obligation — write today.

**AMERCOAT DIVISION**  
**AMERICAN PIPE AND CONSTRUCTION CO.**  
Dept. 3G, 4809 Firestone Blvd., South Gate, Calif.





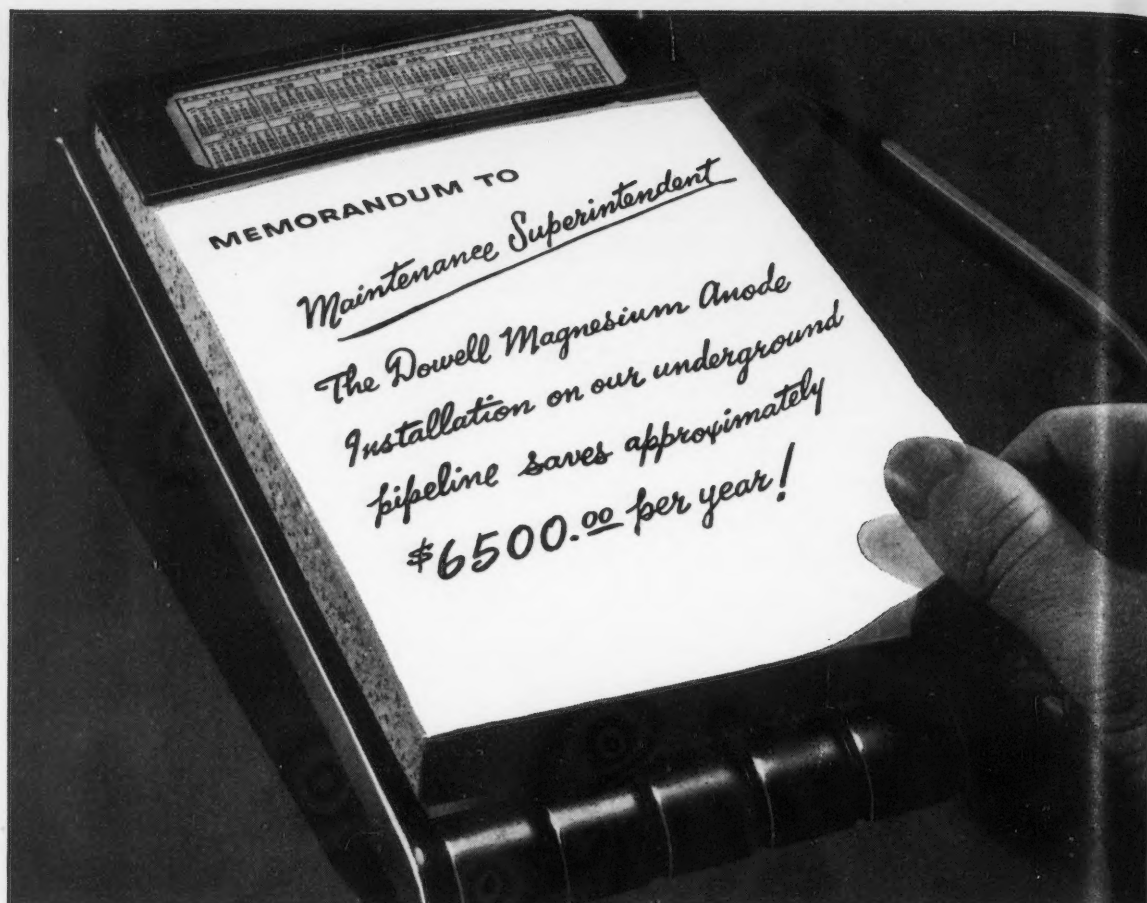
We have coated and wrapped more than 200 million feet of pipe, sizes  $\frac{1}{2}$ " to 60" both inside and outside (and that's a lot of pipe in anybody's language). Ninety-six (96) of the top hands in the business.

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*Permanence*  
IN PIPE"**

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# Corrosion

devoted entirely to

## CORROSION

### Research and Control

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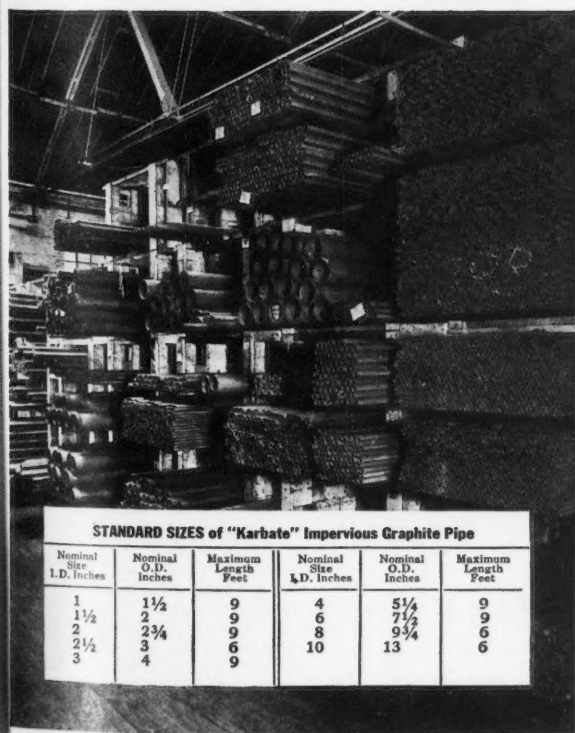
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## HOW TO PREPARE COPY FOR SLIDES

**R**EPRODUCED on this page and the facing page are specimens of lantern slides and lantern slide copy which are considered to be close to ideal. Authors preparing to present papers at meetings of the National Association of Corrosion Engineers will find the condensed instructions included herein sufficient for the preparation of satisfactory lantern slide copy if closely followed.

For those who wish to get a more comprehensive outline of procedures for the preparation of slide copy, numerous monographs are available, including those published by technical and scientific associations at home and abroad. This summary is not intended as a substitute for these more extensive presentations, but for those who wish to get quickly the essentials of the process.

### Size of Copy

Lantern slide copy may be any size. The recommended proportions of the area destined to be projected should be 1:0.8 with the longer side horizontal.

### Size of Lettering

Among the most frequently encountered deficiencies of slides is inadequate lettering—that is, too indistinct to be seen.

Facing this page is a reproduction of a full size piece of copy\* considered nearly ideal for slide production. It is hand-lettered with characters 5/16-inch deep.

\* Figure shown is from "A Geographic Study of Deposits and Corrosion," by F. N. Alquist, CORROSION, 5, No. 2, Page 49, (1949) Feb.

In all but the most favorable conditions it can be postulated:

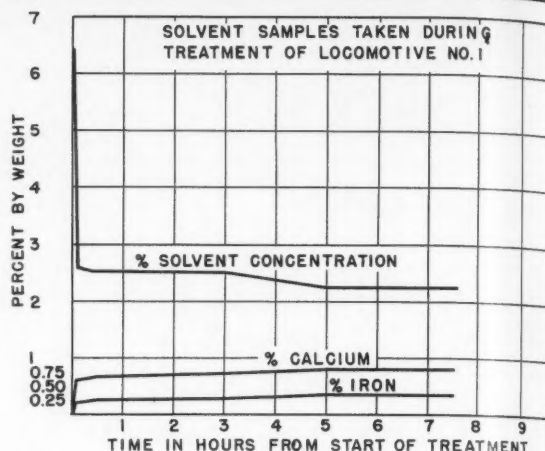
1. Typewriter type is too small for effective copy.
2. Usually the reproduction of typewriter type is too poor for legibility.

NOTE: The size of lettering should increase proportionately if larger copy is used.

No more lettering should be put on the slide than is necessary for its understanding. Lines of letters should be spaced at least one line width apart.

### Width of Letters and Curves

Curves should be of sufficient thickness to be distinctly visible at the maximum distance at which the slide is to be projected. The curve thickness on the specimen copy is correct for 40 feet.



The figure above, a reduced version of the figure on the right hand facing page, is approximately the size of the projection area of a standard slide, 4 x 3 3/4 inches.

Grid lines should be as few as possible, and in many cases can be omitted entirely. The thickness of the grid lines should be about half that of the curve lines.

Factors to be considered in determining the thickness of lines on a graph and the size of letters to be used are:

1. Size of screen.
2. Distance of the last spectator from screen.
3. Efficiency of the projection system under the conditions of the presentation.

For a given screen size the relationship between the thickness of lines and the size of letters on the copy and the distance of the last spectator from the screen is directly proportional; for example, if a letter 5/16 inch in height is necessary at 40 feet for a 7-foot screen, then a letter 3/8-inch in height is necessary for the same screen for 80-foot distances. (These figures are for the size of the letter on the copy.)

### How to Test Copy

Assuming copy for lantern slides is prepared on a letterhead-size sheet, in order to be visible on a 7-foot screen at 40 feet, the lettering on the copy should be legible at a distance of about 10 feet by a person with normal vision.

### Materials to be Used

Plain white bond paper and black India ink are the best materials for the production of line copy.

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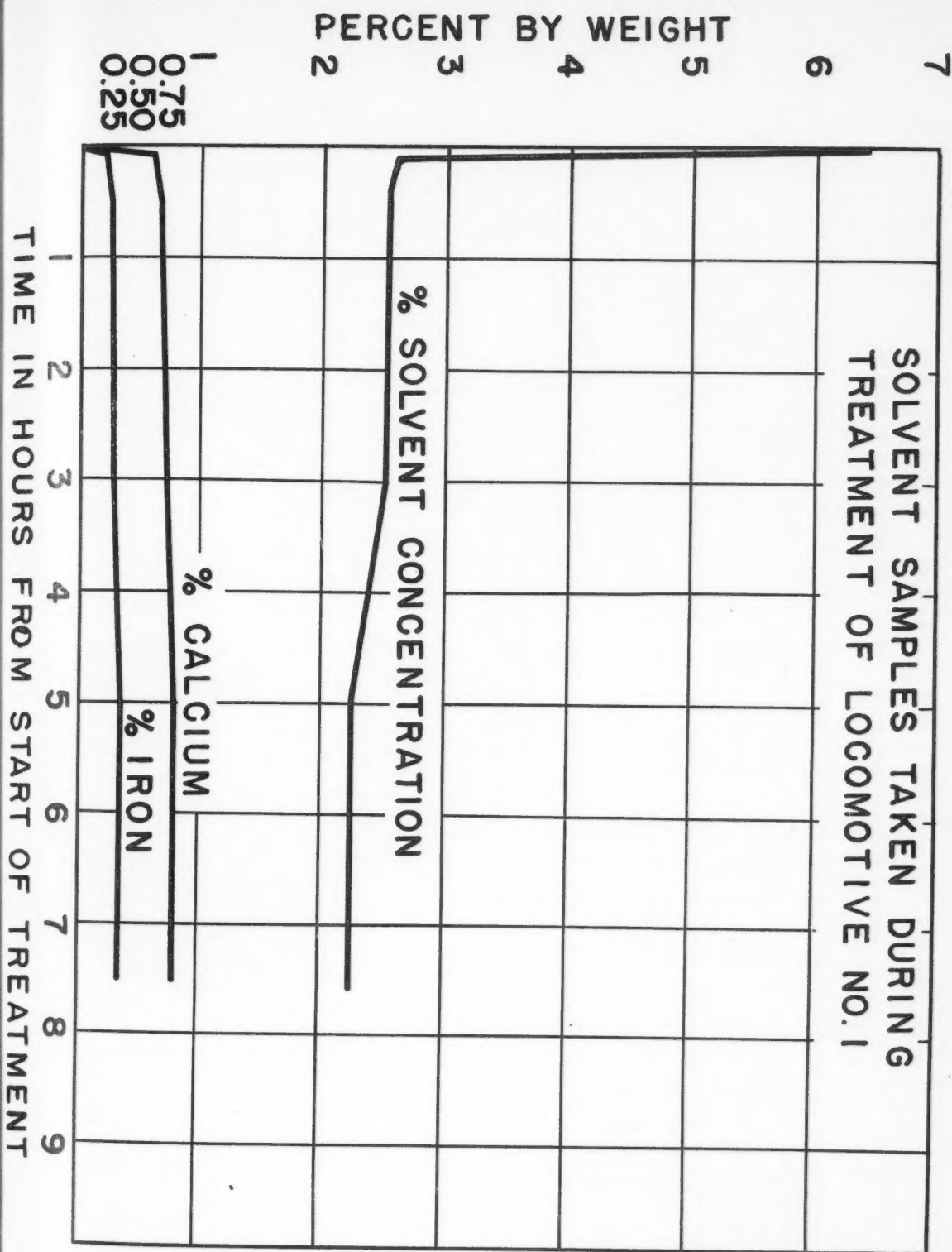
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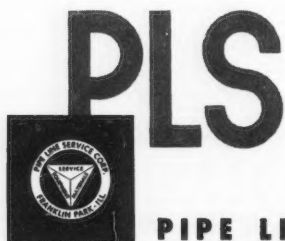




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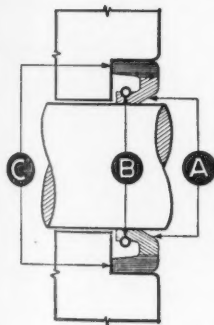
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# Corrosion Tests in the Processing Of Soap and Fatty Acids\*

By W. Z. FRIEND and J. F. MASON, JR.

## Abstract

A summary of the results of corrosion tests made in operating equipment in soap and fatty acid plants during the past 10 years, using mostly the spool-type testing device. Tests in the boiled soap process and glycerine recovery include those in soap kettles, caustic storage, brine tanks, acid and alkali treatment and filtering of soap lye, salt-glycerine slurry, salt-glycerine evaporators and glycerine stills, glycerine bleaching and storage. Tests in fatty acid processing include those in Twitchell and high temperature water splitting of fats, acid washing of fats and fatty acids, deodorization, heating and distillation of animal and vegetable fatty acids including tall oil, fatty acid storage. All tests did not include all of the same metals and alloys but the program included a wide variety of materials such as nickel, Monel, Inconel and other high nickel alloys, stainless steels, copper and copper alloys, aluminum, chemical lead, mild steel, alloy steels and plain and alloy cast irons. Test results are evaluated where possible.

THE GENERAL nature of the corrosives involved in the production of soap and soap lye glycerine has not changed very much during the past ten years. However, there has been a marked increase in the use of more corrosion resisting materials for process equipment, due largely to increased production of higher quality products. Improvement in the color and keeping quality of soap products is largely effected by reducing the amount of metallic pick-up during processing, especially of iron and copper. Consequently, the choice of construction materials often is based largely upon this factor, which may involve relatively small differences in corrosion rates, rather than upon actual equipment life as indicated by relatively large differences in corrosion rates. In recent years, the increased cost of equipment and of maintenance has focused attention upon the need for maximum equipment life and freedom from repairs. This is especially significant with the newly developed continuous soap-making processes.

Principal developments in the fatty acid field have been the large increase in production of the materials and the adoption of continuous fat splitting processes at elevated temperatures and pressures. In addition to expansion in the use of continuous processes for the production of soap by direct neutralization of fatty acids, these acids now are recognized as important starting materials for the synthesis of a wide variety of chemical compounds. Many of these uses demand fatty acids of good color and low metallic content. In the high temperature splitting processes, corrosive conditions are severe enough that only a few construction materials are suitably resistant.

It is obvious that one of the methods for evaluating the various metals and alloys for these services is by making comparative corrosion tests under operating conditions. From the corrosion rates, some estimate of probable metallic pick-up by the product and life of equipment can be made. Original installations of the most promising materials usually were made on the basis of these tests and subsequent service



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\*A paper presented at the Fifth Annual Conference of The National Association of Corrosion Engineers at Cincinnati, Ohio, April 11-14, 1949.



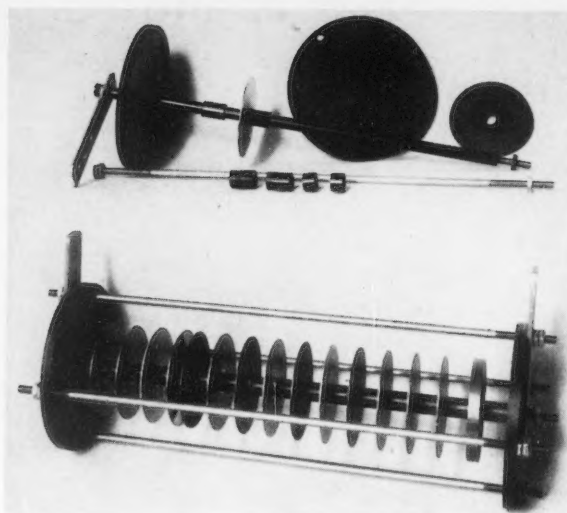


Figure 1—Spool-type specimen holder used in making plant corrosion tests.

experience has shown which materials suitably met the double requirement of corrosion resistance and reasonable annual cost of depreciation and maintenance. The purpose of this paper is to present the results of corrosion tests which have been made in cooperation with the various producers of soap and of fatty acids in plant operating equipment over the past ten to fifteen years. Some plant test corrosion data were presented by Cox in 1938<sup>1</sup> and part of these data have been included in the summaries given herein to make them as complete as possible. An effort has been made to summarize all of the test data in a particular process in one table so the reader

may quickly grasp the variations which may occur from one plant to another and get an overall picture of the relative performance of the various metals and alloys.

Most of the corrosion tests reported here were made with the spool type specimen holder illustrated in Figure 1. This method of testing is substantially in accord with ASTM Recommended Practice for Conducting Plant Corrosion Tests, A224-46.<sup>2</sup> Briefly, the assembly consists of previously cleaned and weighed specimens of the several metals and alloys to be tested, mounted on the spool type holder with nonmetallic parts of porcelain to separate and insulate the specimens from each other and from the metallic parts of the holder. Two similar specimens of each material were included on each spool. The complete test assemblies were fastened firmly in place in the desired test locations in operating plant equipment and allowed to remain for sufficient lengths of time to give reliable indications of corrosion behavior. Each of the test specimens used had an exposed area of 0.5 sq. dm. except where welded specimens were used.

Upon completion of tests, the test spools were removed, dismantled, and the specimens examined, cleaned of all scale and corrosion product, and reweighed. From the weight losses, areas of specimens and duration of exposure, the corrosion rates were calculated in terms of milligrams per square decimeter per day (mdd) and these rates transposed to inch penetration per year (ipy), the unit used in the accompanying tables. This unit is based upon the assumption of uniform corrosion in practice from one side of the metal only. The rate shown for each material is the average of the two specimens included in each test. In addition, each specimen was examined

TABLE I—Nominal Compositions of Metals and Alloys Used in Corrosion Tests

METAL or ALLOY	Percent Nickel	Percent Copper	Percent Chromium	Percent Iron	Percent Molybdenum	Percent Silicon	Percent Manganese	Percent Carbon	Percent Other
Monel.....	67	30	.....	1.4	.....	0.1	1.0	0.15	.....
"K" Monel.....	66	30	.....	0.9	.....	0.5	0.85	0.15	Al 2.75
"S" Monel.....	63	30	.....	2	.....	4	0.75	0.1	.....
Nickel.....	99.4	0.1	.....	0.15	.....	0.05	0.2	0.05	.....
"L" Nickel.....	99.4	0.1	.....	0.15	.....	0.05	0.2	0.02 max.	.....
Inconel.....	78.5	0.2	14	6.5	.....	0.25	0.25	0.08	.....
70-30 Copper-Nickel.....	30	70	.....	.....	.....	.....	.....	.....	.....
Copper.....	.....	99.9	.....	.....	.....	.....	.....	.....	Pb 5, Sn 3, Zn 15
Bronze (85-5-5-5).....	.....	85	.....	.....	.....	.....	.....	.....	Zn 15
Red Brass.....	.....	85	.....	.....	.....	.....	.....	.....	.....
Yellow Brass.....	.....	65	.....	.....	.....	.....	.....	.....	Zn 35
Hastelloy C.....	55	.....	15	6	17	1	1	0.1	W 5
Illium R.....	60	3	21	8	5	0.6	1.25	0.1	W 1
Durimet 20.....	29	4	20	Bal.	3	1	.....	0.07	.....
Pioneer Metal.....	35	.....	25	Bal.	5	.....	.....	0.1	.....
18-8 Stainless (Type 302).....	9	.....	19	Bal.	.....	.....	1.2	0.20 max.	.....
18-8 Stainless (Type 304).....	9	.....	19	Bal.	.....	.....	1.2	0.08 max.	.....
18-8 Cr Stainless (Type 347).....	10	.....	19	Bal.	.....	.....	1.2	0.08 max.	Cb 10xC
18-8 Mo Stainless (Type 316).....	13	.....	18	Bal.	2.25	.....	1.5	0.08 max.	.....
18-8 Mo Stainless (Type 317).....	13	.....	18	Bal.	3.25	.....	1.5	0.08 max.	.....
25-20 Stainless (Type 310).....	20	.....	25	Bal.	.....	.....	1.5	0.20 max.	.....
25-12 Stainless (Type 309).....	13	.....	25	Bal.	.....	.....	1.5	0.20 max.	.....
20-25 Stainless (Type 311).....	25	.....	20	Bal.	.....	.....	.....	0.25 max.	.....
35-15 Stainless (Type 330).....	35	.....	15	Bal.	.....	.....	.....	0.25 max.	.....
17 Cr Stainless (Type 430).....	.....	.....	17	Bal.	.....	.....	1	0.12 max.	.....
13 Cr Stainless (Type 410).....	.....	.....	13	Bal.	.....	.....	1	0.15 max.	.....
4-6 Cr Iron (Type 502).....	.....	.....	5	Bal.	0.5	.....	.....	0.10 max.	.....
Chemical Lead.....	.....	.....	.....	.....	.....	.....	.....	.....	Pb 99.9
Aluminum 2S.....	.....	.....	.....	.....	.....	.....	1.25	.....	Al 99+
Aluminum 3S.....	.....	.....	.....	.....	.....	.....	.....	.....	Al Bal.
Ni-Resist Type 3.....	30	.....	3	Bal.	.....	1.5	0.6	2.75 max.	.....
Ni-Resist Type 2.....	20	.....	2	Bal.	.....	1.8	1.1	3.0 max.	.....
Ni Resist Type 1.....	14.5	6	2	Bal.	.....	1.8	1.3	2.8	.....
Mild Steel.....	.....	.....	.....	Bal.	.....	0.25	0.45	0.2	.....
Cast Iron.....	.....	.....	.....	Bal.	.....	1.8	0.5	3.4	.....

for cracking, pitting, and other forms of local attack. Where pitting or local attack occurred, depth of the five or ten deepest pits was measured microscopically or with a depth gauge. In the accompanying tables, maximum depth of pitting is reported where it occurred.

Approximate compositions of the metals and alloys included in one or more of these tests are shown in Table I.

### Soap Processing

The corrosion test data presented here are confined to the making of boiled process soap, storage and processing of some raw materials, treatment of spent soap lye and recovery of glycerine. Corrosion problems also are involved in soap finishing and corrosion resistant materials are used but the amount of actual corrosion testing in finishing processes has been limited and materials have been selected chiefly upon the basis of experience. Figure 2 is a simplified flow diagram of the processes involved and is presented to indicate the places in which plant corrosion tests included in this summary have been made. Some reference is made to the more corrosion resistant materials now being used in the various processes. Because of the many grades of soap produced, a considerable variety of metals and alloys are used for similar processes throughout the industry. As a general rule, the more corrosion resistant materials are used in the production of high grade white and toilet soaps. Steel, copper and brass equipment are used to a considerable extent in processing other grades of soap because of their cost, and it is assumed that they will be used for this reason wherever quality standards and corrosion resistance permit.

Most of the more corrosion resistant materials such as stainless steels, Monel, nickel and Inconel are available in the form of clad steels and it is recognized that the requirements of the soap industry are particularly adapted to the use of these clad materials wherever size of equipment is such that they offer a price advantage over solid metal construction.

### Raw Materials and Soap Kettle

The crude tallow and vegetable oils usually are stored in steel equipment, although occasionally more corrosion resistant materials are used. In most cases, these crude fats are refined and bleached before further use. In these processes and for the storage of refined fats, considerable use is made of such materials as stainless steels, nickel and Monel for tanks, agitators, steam coils and filter cloths, although specific corrosion test data seem to be lacking.

It is common practice to use nickel-clad steel tanks for the storage of caustic soda solutions of 50 percent concentration or higher, and in some cases for lower concentrations. This follows established practice over many years by the caustic soda producers. Aside from the possibility of iron pick-up in the caustic, welded steel tanks may be subject to caustic embrittlement and cracking if not stress-relieved after fabrication, where called upon to handle hot caustic solutions. General practice in the caustic industry is to avoid the use of unstress-relieved steel

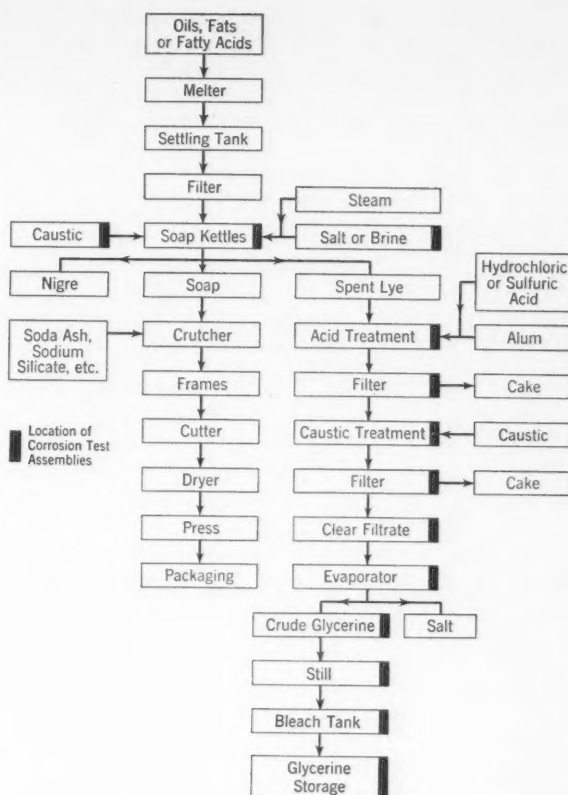


Figure 2—Simplified flow diagram of boiled process soap plant.

vessels for holding 50 percent caustic at temperatures above 140° F. Caustic soda of higher concentrations must be kept hot to prevent solidification in storage so that storage vessels are almost invariably made of nickel-clad steel. The results of plant corrosion tests in the storage of 50 percent and of 75 percent caustic soda are given in Table II.

In the past, some trouble has been experienced from porosity of nickel welds in nickel-clad steel caustic storage tanks. This was particularly troublesome because the welds are difficult to repair once the caustic has worked its way through to the steel at these points. The porosity in some cases was the result of the use of improper welding techniques, but

TABLE II  
Plant Corrosion Tests in Storage of Caustic Soda

Test 1: Immersed in 50% caustic soda solution in storage tank. Temperature 130-165° F. Duration of test 30 days.<sup>1</sup>  
Test 2: Immersed in 70% caustic soda in receiving tank. Temperature 190-235° F. Duration of test 35 days.

Material	Corrosion Rate, Inch per Year	
	Test 1	Test 2
Nickel.....	0.00002	0.0001
Monel.....	0.00003	0.0011
Inconel.....	0.00002	0.0003
Type 304 Stainless.....	0.0001	0.027
Ni-Resist (Type 1).....	0.0020	.....
Cast Iron.....	0.011	.....
Mild Steel.....	0.010	0.057

in other cases could rightfully be blamed upon the welding electrode. In recognition of this fact, an improved nickel welding electrode was developed and put upon the market about two years ago, which is exceptionally free from any tendency to porosity.

**TABLE III**  
**Plant Corrosion Test in Salt Brine Tank<sup>1</sup>**

Immersion in salt brine tank in solution of salt recovered from glycerine evaporator. Heated by live steam injection. Temperature 100-200° F. Duration of test 78 days. Plant 1.

Material	Corrosion Rate, Inch per Year
Monel.....	0.0004
Nickel.....	0.0004
Inconel.....	0.0004
Ni-Resist (Type 2).....	0.0014
Ni-Resist (Type 1).....	0.0006
Cast Iron.....	0.030
Mild Steel.....	0.022

**TABLE IV**  
**Plant Corrosion Test in Soap Boiling Kettle**

Immersed near top of settling cone of soap boiling kettle during saponification and graining. Boiled with live steam. Temperature 160-212° F. Duration of test 106 days.

Material	Corrosion Rate, Inch per Year
Monel.....	<0.0001
Nickel.....	<0.0001
Inconel.....	<0.0001
Ni-Resist (Type 1).....	0.0001
Cast Iron.....	0.011
Mild Steel.....	0.0032

<—Less than.

**TABLE V—Plant Corrosion Tests in Acid Treatment of Spent Soap Lye**

**Test 1:** Immersed in acid treating tank in mixture of 13% NaCl and 4.5% glycerine to which is added 150 lbs. of 28% HCl and 75 lbs. of 17% aluminum sulfate per 30,000 lbs. soap lye. Plant 1. Temperature: 30-180° F. Duration of test 167 days.<sup>1</sup>

**Test 2:** Immersed half-way down in acid treating tank in mixture of 18% NaCl plus glycerine to which is added 0.5% of a 50% solution of aluminum chloride. Aerated. Average temperature 165° F. Duration of test 65 days. Plant 2.

**Test 3:** Immersed in trough of filter in acid treated filtrate from Test 2. Aerated. Average temperature 160° F. Duration of test 65 days. Plant 2.

**Test 4:** Immersed half-way down in acid-treating tank in mixture of 8 to 10%

Since that time, very little trouble has been experienced from this source.

In general, it can be said that in the fabrication of a vessel of any clad-steel material, it is not advisable to attempt to grind down the welds on the clad side. Aside from the possibility of opening up some covered pores, the grinding of welds tends to expose weld metal of a higher iron content than in the top weld bead. Also, there is a possibility of a slip of the grinding tool perforating the cladding if the latter is thin.

Nickel-clad steel and Monel are used for the construction of brine storage tanks particularly where the brine is kept hot. Under such conditions, the corrosion rate of mild steel sometimes can be fairly high, as indicated by the corrosion test results in Table III. In this case, the salt used was recovered from the glycerine evaporator and was kept as hot as 200° F by admission of live steam. The same materials sometimes are used for rock salt dissolving tanks as well as for salt bins and chutes in a further effort to reduce iron contamination. The stainless steels have only limited application in the processes where salt is involved because of the tendency of these alloys, particularly Types 302, 304 and 347, to pitting in chloride solutions.

The matter of iron contamination is particularly significant in the soap boiling kettles because the soap spends so much time there, particularly in the full-boiled process. This is especially significant in the upper parts of the kettles where corrosion rates are highest. Consequently, some of the earliest appli-

NaCl and 4.5% glycerine made acid to pH 4.5 with HCl and ferric chloride. Air agitation. Temperature 70-160° F. Duration of test 28 days. Plant 3.

**Test 5:** In acid treating tank in spent soap lye made acid to pH 4.5 with HCl ferric chloride, and aluminum sulfate. Agitated with air. Temperature 130-174° F. Duration of test 45 days. Plant 3.

a—Immersed in bottom of tank near air inlet.  
b—In vapor in top of tank.

**Test 6:** Immersed half-way down in solution containing 13-16% NaCl plus Na<sub>2</sub>SO<sub>4</sub> and 10-12% glycerine made acid to pH 4.5 with sulfuric acid and ferric chloride. Aerated. Temperature 90-212° F. (Ave. 185° F.). Duration of test 105 days. Plant 4.

Material	Corrosion Rate, Inch per Year						
	Test 1 Plant 1	Test 2 Plant 2	Test 3 Plant 2	Test 4 Plant 3	Test 5a Plant 3	Test 5b Plant 3	Test 6 Plant 4
Monel.....	0.0009	0.0003	0.0048	0.0029	0.0056	0.0044	0.016
Nickel.....	0.0011	0.0009	0.0037	0.0018	0.0051	0.0047	0.010
Inconel.....	0.0006	<0.0001	0.0007	0.0008	.....	.....	0.0007
18-8 Stainless (Type 302).....	.....	<0.0001	0.0007a	0.0005c	.....	.....	.....
18-8 Stainless (Type 304).....	.....	.....	.....	0.0005c	.....	.....	0.0010b
18-8 Mo Stainless (Type 316).....	.....	<0.0001	0.0004b	.....	.....	.....	0.0010i
70-30 Copper-Nickel.....	.....	.....	.....	.....	.....	.....	0.027
Aluminum 2S.....	.....	.....	.....	0.0044d	.....	.....	.....
Ni-Resist (Type 3).....	.....	.....	.....	.....	.....	.....	0.0030
Ni-Resist (Type 2).....	0.0027	0.0010	0.0040	.....	.....	.....	.....
Ni-Resist (Type 1).....	0.0025	0.0009	0.0034	.....	.....	.....	0.0050
Mild Steel.....	0.0053	0.0030	0.017	0.016	0.029e	0.034g	0.014
Wrought Iron.....	.....	.....	.....	0.018	0.024f	0.044g	0.014
Cast Iron.....	0.011	0.0060	0.016	.....	.....	.....	0.014

a—Perforated by pitting, original thickness 0.031 inch.

b—Pitted to maximum depth of 0.011 inch.

c—Pitted to maximum depth of 0.005 inch.

d—Pitted to maximum depth of 0.003 inch.

e—Pitted to maximum depth of 0.020 inch.

f—Pitted to maximum depth of 0.009 inch.

g—Pitted to maximum depth of 0.008 inch.

h—Pitted to maximum depth of 0.006 inch.

i—Pitted to maximum depth of 0.014 inch.

<—Less than.



TABLE VI—Plant Corrosion Tests in Alkali Treatment of Spent Soap Lye

**Test 1:** Immersed in treating tank during alkali treatment of acidified soap lye containing 13% NaCl and 4.5% glycerine. 25 lb. of 50% NaOH added to 30,000 lbs. of solution. Temperature 160-180° F. Duration of test 123 days. Plant 1.<sup>1</sup>

**Test 2:** Immersed in treating tank during alkali treatment of acidified soap lye containing 18% NaCl plus glycerine to give 0.003% free Na<sub>2</sub>O. Average temperature 160° F. Duration of test 65 days. Plant 2.

**Test 3:** Immersed in trough of second filter in alkali treated filtrate from Test 2. Average temperature 140° F. Duration of test 65 days. Plant 2.

**Test 4:** Immersed half-way down in second treating tank during alkali treatment of acidified soap lye from pH 4.5 to pH 8.5. Solution contained 8% NaCl and 4.5% glycerine. Air agitation. Temperature 70-180° F. Duration of test 28 days. Plant 3.

**Test 5:** Immersed in second treating tank during alkali treatment of acidified soap lye from pH 4.5 to pH 9.0. Solution contains 10-12% glycerine and 13-16% NaCl plus Na<sub>2</sub>SO<sub>4</sub>. Temperature 90-203° F. (Average 185° F.). Duration of test 105 days. Aerated. Plant 4.

a—Test spool located 18" above bottom of tank.  
b—Test spool located 7 ft. above bottom of tank.

Material	Corrosion Rate, Inch per Year					
	Test 1 Plant 1	Test 2 Plant 2	Test 3 Plant 2	Test 4 Plant 3	Test 5a Plant 4	Test 5b Plant 4
Monel.....	0.0007	0.0003	0.0001	0.0006	0.006	0.007
Nickel.....	0.0008	0.0003	0.0004	0.0006	0.007	0.006
Inconel.....	0.0005	0.0002	0.0005	0.0001	0.006b	0.004e
70-30 Copper-Nickel.....	.....	.....	.....	.....	0.011	0.012
18-8 Stainless (Type 302).....	.....	0.0002	0.0004	0.0001a	.....	.....
18-8 Stainless (Type 304).....	.....	.....	.....	0.0001a	0.006c	0.004d
18-8 Mo Stainless (Type 316).....	.....	0.0001	0.0002	.....	0.003d	0.003
Ni-Resist (Type 3).....	.....	.....	.....	.....	0.007	0.007
Ni-Resist (Type 2).....	0.0021	0.0008	0.0024	.....	.....	.....
Ni-Resist (Type 1).....	0.0015	0.0004	0.0011	.....	0.009	0.010
Mild Steel.....	0.011	0.059	0.038	0.029	0.042	0.020
Wrought Iron.....	.....	.....	.....	0.033	0.035	0.021
Cast Iron.....	0.028	0.12	0.074	.....	0.023	0.035

a—Pitted to maximum depth of 0.004 inch.  
b—Pitted to maximum depth of 0.022 inch.

c—Pitted to maximum depth of 0.030 inch.  
d—Pitted to maximum depth of 0.040 inch.  
e—Pitted to maximum depth of 0.023 inch.

TABLE VII

## Plant Corrosion Test in Treated Glycerine Lye Storage Tank

Test specimens located 20 inch from top of tank so were alternately immersed and exposed to vapor. Approximate composition: 10-12% Glycerine, 13-16% NaCl plus Na<sub>2</sub>SO<sub>4</sub>. Temperature 165-185° F. (Average 175° F.). Duration of test 105 days. Plant 4.

Material	Corrosion Rate, Inch per Year
Monel.....	0.0001
Nickel.....	0.0004
Inconel.....	0.0001a
70-30 Copper-Nickel.....	0.0001
18-8 Stainless (Type 304).....	0.0001a
18-8 Mo Stainless (Type 316).....	0.0001
Ni-Resist (Type 3).....	0.0020
Ni-Resist (Type 1).....	0.062
Cast Iron.....	0.058
Wrought Iron.....	x
Mild Steel.....	0.051b

x—Completely destroyed during test. Original thickness 0.031 inch.

a—Pitted to maximum depth of 0.007 inch.

b—Perforated by pitting. Original thickness 0.038 inch.

cations of corrosion resistant materials were in the construction of soap kettles. The first step in most cases, was to line the upper portions of existing steel kettles with Monel or stainless steel sheet. As new kettles were built, these sometimes were constructed completely of nickel-clad\*steel. At present, most of the kettles for production of higher grade soaps are constructed by one of these methods. The same materials also are used for heating coils, swing pipes, kettle covers and other accessory equipment. Table IV gives the results of a 106-day plant test in a soap kettle.

## Soap Lye Treatment

Much of the corrosion test work in soap plants has been done in the treatment of spent soap lye and recovery of glycerine since these processes represent particularly corrosive conditions. The pH of the solution during acid treatment is usually 4 to 4.5 and sometimes as low as pH 3, due to hydrochloric or sulfuric acids. The fact that the mixtures often are agitated with air tends to increase the corrosion rate of steel. The results of seven plant tests during acid treatment of soap lye in four different soap plants are shown in Table V. Test 3 was made in the filtrate in the trough of the filter following acid-treatment. By comparison with Test 2, made in the adjoining treating tank at the same plant, it will be seen that the filtrate was more corrosive than the mixture during treatment. This could be accounted for by the possible inhibiting action of soaps and albuminous materials present during treatment and subsequently filtered out. The same factor might account for the fact that the corrosion rate of some materials such as mild steel is higher during alkali treatment of the filtrate than during acid treatment of the soap lye as indicated by comparing the data in Tables V and VI. Table VI gives the results of tests during alkali treatment in the same four plants in which the other tests were made. This usually is accomplished by adding sodium hydroxide to a pH of 8-9.

Monel and nickel or nickel-clad are in some cases used for both acid treating and caustic treating tanks and for connecting piping and accessory equipment. Type 3 Ni-Resist, having low expansion coefficient, is used for the construction of soap lye filters and filter plates because there may be some thermal shock

TABLE VIII

## Plant Corrosion Tests in Crude Glycerine Evaporators

- Test 1:** Immersed in liquid above top tube sheet of evaporator. Initial concentration: 13% NaCl, 4.5% glycerine. Final concentration: 8% NaCl, 81% glycerine. Average temperature 175° F. Duration of test 63 days. Under vacuum. Plant 1.<sup>a</sup>
- Test 2:** Same as Test 1, three years later. Duration of test 93 days. Plant 1.
- Test 3:** In liquid splash and vapor about 2 ft. above top tube sheet of evaporator. Initial concentration: 13% NaCl, 4.5% glycerine. Final concentration 8% NaCl, 81% glycerine, pH 5.5 to 6.5. Under 25 in. Hg. vacuum. Temperature 140-175° F. Duration of test 55 days. Plant 1.
- Test 4:** In garrique evaporator under 25-29 in. Hg. vacuum. Initial concentration 10% NaCl, 5% glycerine. Final concentration 8% NaCl, 80% glycerine. Temperature 150-165° F. Duration of test 33 days. Plant 5.
- A—Immersed in liquid at bottom of evaporator.  
B—In vapor at top of evaporator.

MATERIAL	Corrosion Rate, Inch per Year				
	Test 1 Plant 1	Test 2 Plant 1	Test 3 Plant 1	Test 4A Plant 5	Test 4B Plant 5
Monel.....	<0.0001	<0.0001	0.0002	0.0013	0.0007
Nickel.....	<0.0001	0.0001	0.0003	0.0012	0.0006
Inconel.....	<0.0001	0.0001	<0.0001	0.0005	0.0004e
Copper.....	.....	.....	.....	0.0090	0.016
18-8 Stainless (Type 302).....	.....	0.0002a	.....	.....	.....
18-8 Stainless (Type 304).....	.....	0.0002b	.....	.....	.....
Ni-Resist (Type 3).....	.....	0.0001	.....	0.0030	0.0030
Ni-Resist (Type 2).....	0.0001	0.0002	0.0008	0.0050	0.0050
Ni-Resist (Type 1).....	0.0005	.....	0.0006	0.0050	0.0060
Cast Iron.....	0.0009	0.0005	0.0056	0.029	0.058
Wrought Iron.....	.....	0.0007c	.....	.....	.....
Mild Steel.....	0.0004	0.0010d	0.0056	0.21	0.063

- a—Pitted to maximum depth of 0.009 inch.  
b—Pitted to maximum depth of 0.010 inch.  
c—Pitted to maximum depth of 0.004 inch.  
d—Pitted to maximum depth of 0.005 inch.  
e—Pitted to maximum depth of 0.006 inch.  
—Less than.

TABLE IX

## Plant Corrosion Tests in Salt-Glycerine Slurry

- Test 1:** In tank through which salt-glycerine slurry from crude glycerine evaporator circulates to Bird centrifugal. Composition of liquid: 24.9% NaCl, 34.3% glycerine, 1.8% Na<sub>2</sub>SO<sub>4</sub>, 0.001% free Na<sub>2</sub>O. Composition of crystalline solids: 81.8% NaCl, 18.1% Na<sub>2</sub>SO<sub>4</sub>. Agitated with air. Temperature 100-220° F. (Average 150° F.). Duration of test 30 days. Immersed in slurry approx. 1/2 of time. Subject to wash from feed pipe balance of time. Plant 7.
- Test 2:** In salt-glycerine slurry tank. Composition of total slurry: 52% NaCl, 25% glycerine, 5% Na<sub>2</sub>SO<sub>4</sub>, balance water. Immersed 6 ft. from top of tank, immersed part of time and subject to wash from feed pipe part of time. Agitated with air. Temperature 100-200° F. (Ave. 180° F.). Duration of test 23 days. Plant 8.

Material	Corrosion Rate, Inch per Year	
	Test 1 Plant 7	Test 2 Plant 8
Monel.....	0.0001	0.0004
"K" Monel.....	0	0.0001
"S" Monel.....	0.00001	0.0002
Nickel.....	0.0001	0.0004
Inconel.....	0.0002	0.0001
Ni-Resist (Type 1).....	0.0001	0.0004
Mild Steel.....	0.016a	0.0034b

- a—Pitted to maximum depth of 0.005 inch.  
b—Pitted to maximum depth of 0.002 inch.

TABLE X

## Plant Corrosion Test in Crude Glycerine in Scale Tank

- Test spool immersed half-way down in scale tank in crude glycerine containing 81% glycerine, 8-10% NaCl and 7% water. Pumped in and out of tank continuously at approximate rate of 200 lb. per min. Temperature 70 to 280° F. (Average 240° F.). Duration of test 31 days. Plant 3.

Material	Corrosion Rate, Inch per Year
Monel.....	<0.0001
Nickel.....	<0.0001
Inconel.....	<0.0001
18-8 Stainless (Type 304).....	<0.0001a
Aluminum 2S.....	0.003b
Wrought Iron.....	0.002
Mild Steel.....	0.001

- a—Pitted to maximum depth of 0.004 inch.  
b—Pitted to maximum depth of 0.008 inch.  
—Less than.

when the hot solutions enter a cold filter press. Pumps of nickel-chromium-molybdenum-iron alloys such as Worthite and Durimet have given good performance handling both acid and alkali treated soap lye.

The results of a corrosion test in storage of treated glycerine lye solution prior to evaporation, are shown

## Glycerine Evaporation and Distillation

A number of plant corrosion tests were made in crude glycerine evaporators and the results are summarized in Table VIII. These evaporators commonly are made with cast iron bodies and with copper heating coils and condenser tubes. This construction has appeared to be generally satisfactory, although in some cases, corrosion rates of these materials can be appreciable as indicated by Tests 4A and 4B. In such cases, evaporators have been satisfactorily constructed with nickel-clad steel shells and nickel tubes. It would appear that excessive corrosion of iron may be associated with those solutions which have a lower pH value than usual. In some cases, this may be done purposely in order to control side reactions during evaporation. In other cases, it may be due to lack of accurate control of alkalinity during treating. In such cases, it would seem that corrosion of cast iron and copper equipment might possibly be reduced by use of automatic pH controlling instruments to govern alkali additions to the soap lye rather than to rely entirely upon tests made upon grab samples with indicators such as phenol-phthalein.

The corrosion tests reported in Table IX were made in tanks handling the salt-glycerine slurry discharged from evaporators just prior to centrifuging. The slurry tanks or salt catchers are, in some plants, constructed of nickel-clad steel or Monel where mild steel has proved to corrode excessively. Continuous centrifugals are in some cases constructed of Monel with slotted Monel or Type 316 stainless screens. Silicon Monel castings, such as "H" Monel or "S" Monel, are used for parts which must be resistant to abrasion by the crystalline salt at high velocities. Some preliminary study has been made of the effect of alkalinity of the glycerine-salt solution upon the life of Monel screens. In one plant, the life of screens as determined by enlargement of slots, was increased considerably when the total Na<sub>2</sub>O content of the slurry was increased from .002-.007 percent up to .013-.017 percent.

Table X gives the results of tests made in a crude glycerine scale tank through which the 81 percent glycerine product is circulated after evaporation.

The test results reported in Table XI were made during the steam distillation of crude glycerine. In view of the higher temperatures encountered and the fact that the feed to these stills contains from 4 to 10 percent salt, corrosion rates of iron and steel generally are higher than in the crude glycerine evaporators. Both solid nickel and nickel-clad steel stills are at present being used with nickel steam coils.

The results of two plant corrosion tests during carbon bleaching of glycerine are given in Table XII. To complete this series of tests in glycerine processing, the results of tests of storage of finished high strength glycerine are given in Table XIII. It will

be noted that corrosion rates are extremely low under storage conditions. Aluminum commonly is used for storage and transportation.

In the synthesis of glycerine from petroleum, the crude glycerine produced also contains a certain amount of salt resulting from the reaction of caustic soda with chlorohydrin so that corrosion problems in the glycerine distillation are somewhat the same as in the distillation processes described above. In a synthetic plant<sup>3</sup> nickel and nickel-clad steel are used for the construction of glycerine stills.

Several processes for continuous production of soaps are now in operation. One of these in which soap is produced by direct neutralization of fatty

acids with caustic soda was described by McBride.<sup>4</sup> The plant involves the use of considerable amounts of stainless steels. Another process is a continuous adaptation of the former full boiled batch process involving saponification of fats. The corrosives handled are much the same as in the batch boiled process and the selection of corrosion resisting materials is about the same. Nickel and nickel-clad steel are used for caustic tanks and circulating lines and for brine heaters and circulating lines, Type 316 stainless steel for fat heaters and circulating lines, nickel for soap and lye lines, Ni-Resist for proportioning pumps and forged Inconel bowls are used in some of the super centrifuges.

TABLE XI

## Plant Corrosion Tests in Glycerine Stills

**Test 1:** In atmospheric pressure evaporator. Temperature 320° F. Plant 4.  
A—Immersed in bottom of evaporator. Duration of test 124 days.  
B—Located above heating coils where agitation greatest. Duration of test 42 days.

**Test 2:** In evaporator operating under 10 in. Hg. vacuum. Temperature 300° F. Plant 6.  
A—Immersed in liquid. Duration of test 27 days.  
B—In vapor at top of evaporator. Duration of test 88 days.

Material	Corrosion Rate, Inch per Year			
	Test 1A Plant 4	Test 1B Plant 4	Test 2A Plant 6	Test 2B Plant 6
Monel.....	0.0024	0.0047	0.0014	0.0016
Nickel.....	0.0016	0.0026	0.0009	0.0016
Inconel.....	.....	.....	<0.0001	<0.0001
70-30 Copper-Nickel.....	.....	.....	0.0023	0.0046
Copper.....	0.0085	0.015	0.0035	0.014
Red Brass.....	.....	.....	0.0038	0.013
18-8 Stainless (Type 302).....	0.0079a	.....	0.0027	0.0004g
18-8 Stainless (Type 304).....	.....	0.010e	.....	0.0003h
18-8 Mo Stainless (Type 316).....	0.0078b	0.019f	0.0020	0.012
Ni-Resist (Type 1).....	.....	.....	0.013	0.079
Cast Iron.....	.....	.....	0.079	0.037
4-6 Cr. Steel (Type 502).....	0.038c	0.045	0.042	0.030 i
Wrought Iron.....	.....	.....	0.033	0.031 i
Mild Steel.....	0.034d	0.032	0.035	.....

a—Pitted to maximum depth of 0.003 inch.  
b—Pitted to maximum depth of 0.007 inch.  
c—Pitted to maximum depth of 0.005 inch.  
d—Pitted to maximum depth of 0.010 inch.  
e—Pitted to maximum depth of 0.009 inch.  
f—Pitted to maximum depth of 0.004 inch.  
g—Pitted to maximum depth of 0.006 inch.  
h—Pitted to maximum depth of 0.009 inch.  
i—Specimens perforated by pitting. Orig. thickness 0.031 inch.  
—Less than.

TABLE XII

## Plant Corrosion Tests in Bleaching of Glycerine

**Test 1:** Immersed half-way down in bleaching tank in 95% glycerine, 5% water plus bleaching carbon. pH 6-7. Mild air agitation. Temperature 100-250° F (Average 140° F). Duration of test 33 days. Plant 3.

**Test 2:** In glycerine bleach tank during bleaching with carbon. Temperature atmospheric. Duration of test 100 days. Plant 4.<sup>1</sup>  
A—Fully immersed.  
B—Floating at liquid level.

Material	Corrosion Rate, Inch per Year		
	Test 1 Plant 3	Test 2A Plant 4	Test 2B Plant 4
Monel.....	<0.0001	<0.0001	0.0001
Nickel.....	0.0001	0.0020	0.0016
Inconel.....	<0.0001	<0.0001	0.0001
Copper.....	.....	0.0018	0.0013
Yellow Brass.....	.....	0.0008	0.0013
Bronze (85-5-5-5).....	.....	0.0020	0.0017
Aluminum 2S.....	<0.0001	0.0001	0.0005
Chemical Lead.....	.....	0.036	0.046
17% Cr Steel (Type 430).....	.....	<0.0001	0.0003
18-8 Stainless (Type 304).....	<0.0001	<0.0001	0.0002
Wrought Iron.....	0.0007	0.0014	0.0027
Mild Steel.....	0.0007a	0.0014	0.0030

a—Pitted to maximum depth of 0.009 inch.  
—Less than.

## Fatty Acid Processing

Fatty acid is produced principally by the hydrolysis or splitting of tallow and animal grease though increasing amounts now are being produced by the splitting of other fats such as fish, coconut and cottonseed oils. The most commonly used process for splitting is still the Twitchell process involving treatment of the fat at atmospheric pressure with steam in the presence of a small amount of sulfuric acid and Twitchell reagent (naphthalene sulfonic acid). Concentrated sulfuric acid is added to the extent of about 1 to 1.5 percent of the weight of the fat and the mixture agitated with live steam so that the temperature of the mixture is in the neighborhood of 212° F. Because this represents a corrosive condition, a considerable number of plant corrosion tests have been made in Twitchell splitting tanks with results summarized in Table XIV. They include tests both immersed and at the liquid level. While numerous splitting tanks still are constructed of wood, copper or lead-lined steel, a good many of the larger splitting tanks now are constructed of Monel or lined with this alloy, with steam coils and fittings of the same material. General experience has been that corrosion rates of Monel are low enough that there is no objectionable effect upon the color of the product. One case has been encountered in which the splitting tank was small and the fatty acids were not distilled sub-

TABLE XIII

## Plant Corrosion Tests in Finished Glycerine Storage

**Test 1:** Immersed half-way down in storage tank in finished glycerine containing 95% glycerine and 5% water. pH 6-7. Temperature 100-170° F (Average 130° F). Duration of test 32 days. Plant 3.

**Test 2:** Partially immersed at surface of finished glycerine in storage tank. Temperature atmospheric. Duration of test 250 days. Plant 4.<sup>1</sup>

Material	Corrosion Rate, Inch per Year	
	Test 1 Plant 3	Test 2 Plant 4
Monel.....	0	<0.00001
Nickel.....	<0.00001	0.00002
Inconel.....	<0.00001	<0.00001
Copper.....	.....	0.00003
Aluminum 2S.....	0.00002	0.00002
18-8 Stainless Steel (Type 304).....	<0.00001	<0.00001
Wrought Iron.....	0.00006	0.00008
Mild Steel.....	0.00007	0.00008
Cast Bronze.....	.....	0.00004

—Less than.



TABLE XIV—Plant Corrosion Tests in Twitchell Process of Fat Splitting

Fats or oils are mixed with about 1 to 1.5% by weight of 66° Bé sulfuric acid and Twitchell reagent. Heated and agitated with live steam. Boiling period approximately 24 hours for each batch. Specimens immersed in mix-

ture and at liquid-air level. Number of batches 8 to 12 per month. Temperature approximately 100° C. (212° F.). Duration of tests 21 to 83 days.

Material	CORROSION RATE, INCH PER YEAR*								
	Test 1 83 Days	Test 2 65 Days	Test 3 61 Days		Test 4 38 Days	Test 5 43 Days	Test 6 21 Days		Test 7 60 Days
	In Liquid	At Liquid Level	In Liquid	At Liquid Level	At Liquid Level	In Liquid	Bottom of Tank	Just Below Liquid Level	In Liquid
Monel.....	0.0025	0.0026	0.0007	0.0022	0.0031	0.0027	0.0090	0.0025	0.0015
Nickel.....	0.013	0.018	0.010	0.0145	0.0087	0.0092	0.039	0.0034	.....
Inconel.....	0.0050	0.0050	0.003	0.0042	0.0027	0.0085	0.011	0.0042	.....
Copper.....	0.0034	0.0023	0.0012	0.0052	0.0015	.....	0.0087	0.0033	.....
Cast Bronze.....	.....	.....	0.0016	0.0088	.....	.....	.....	.....	.....
Chemical Lead.....	.....	.....	0.013	0.091	.....	.....	.....	.....	.....
Aluminum 2S.....	.....	.....	x	x	x	.....	.....	.....	.....
18-8 Stainless (Type 304).....	0.011	0.017	0.018	0.023	0.0092	0.021	0.0050	0.057	.....
18-8 Mo Stainless (Type 316).....	.....	.....	.....	.....	.....	0.0050	0.0010	0.0031	.....
25 Cr-12Ni Stainless (Type 309).....	.....	.....	.....	.....	.....	0.018	.....	.....	.....
Ni-Resist (Type 1).....	.....	.....	.....	.....	0.015	.....	.....	.....	.....
Cast Iron.....	.....	.....	.....	.....	0.071	.....	.....	.....	.....

x—Corroded entirely away. Original thickness 0.032 inch.

\*—Tests 1, 2, 3, 4 and 5 from Reference 1.

TABLE XV

## Plant Corrosion Test in Straight Sulfuric Acid Splitting of Olive Oil

Immersed at center of splitting tank about 3 ft. above bottom, during splitting with 0.3 to 0.5% by wt. of 66° Bé sulfuric acid. Agitated with air during mixing. Each batch requires about 1½ hrs. Duration of test 21 days (15 splits). Temperature 50-90° C (120-190° F).

Material	Corrosion Rate, Inch per Year
Monel.....	0.0010
Nickel.....	0.0023
Inconel.....	<0.0001
Ni-Resist (Type 1).....	0.010
Cast Iron.....	0.061
Chemical Lead.....	0.011

<—Less than.

TABLE XVI

## Plant Corrosion Tests in Continuous Counter-Current Fat Splitting Tower

(Duration of Tests 1650 Hours)

Material	Type Specimen	Corrosion Rate, Inch per Year		
		Top of Tower	Middle of Tower	Bottom of Tower
Test Program No. 1:				
Type 316 Stainless (0.03 Max. C).....	Cross Weld	0.0005	0.0004	0.0002
Type 316 Stainless (0.03 Max. C).....	Beam	0.0005	0.0004	0.0004
Inconel (13.6% Cr).....	Cross Weld	0.0074	0.0083	0.0007
Inconel (13.6% Cr).....	Beam	0.0077	0.0078	0.0017
'L' Nickel.....	Cross Weld	0.009	0.012	0.019
'L' Nickel.....	Beam	0.011	0.012	0.015
Test Program No. 2:				
Type 316 Stainless (0.03 Max. C).....	Cross Weld	0.0006	0.0005	0.0004
Inconel (16.4% Cr).....	Butt Weld	0.0040	0.0014	0.0006
Inconel (17.9% Cr).....	Sheet	0.0030	0.0014	0.0009
80 Ni-20 Cr Alloy.....	Butt Weld	.....	.....	0.0009
80 Ni-20 Cr Alloy.....	Beam	.....	.....	0.0009

sequently, where there appeared to be some slight effect of copper pick-up from the Monel upon the color of the stearic acid produced. In this case, the ratio of tank volume in cubic feet to inside tank area in square feet was less than 2½ to 1 and it is possible that this might be considered as a limiting ratio where no subsequent distillation is to be performed and color is very important.

In a few cases, splitting of fats is done with sulfuric acid and steam without use of Twitchell re-

agent. The results of a test in the straight sulfuric acid splitting of olive oil are given in Table XV.

One of the most interesting developments in fatty acid production is the use of continuous counter-current high temperature splitting of fats with hot water. One of these processes described by McBride<sup>4</sup> operates at about 490° F under about 600 lb. per sq. in. pressure. Another process described by Barnebey and Brown<sup>5</sup> operates at about 500° F and about 725 lb. per sq. in. pressure. The particular advantages claimed for these processes, aside from the high production rates resulting from continuous operation, include high splitting efficiency and improved fatty acid color.

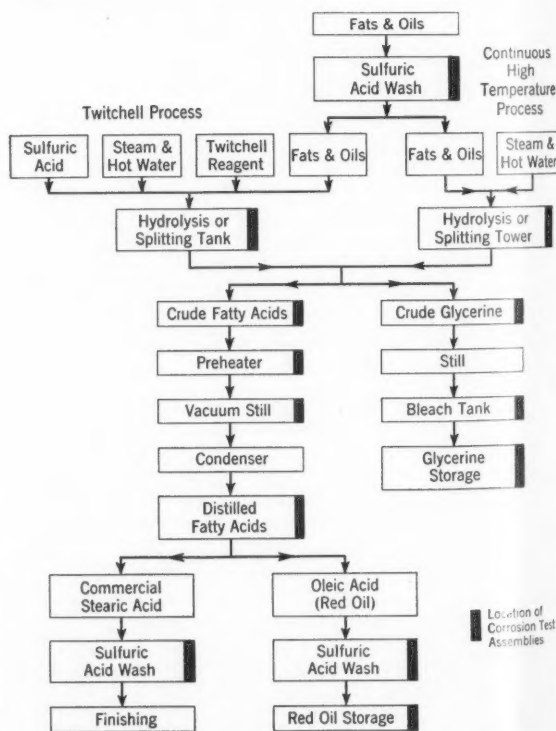


Figure 3—Simplified flow diagram of plant producing fatty acids by hydrolysis.

Because of the high temperatures and pressures employed, the selection of materials for construction of splitting columns has been the subject of considerable study. The fact that the fatty acids are mixed with water at these high temperatures would be expected to make corrosive conditions somewhat more severe than in dry fatty acids at the same temperatures, so that experience with fatty acid stills could not be relied upon entirely for the splitting process. Preliminary pilot plant corrosion tests showed Type 316 stainless steel, 80 nickel-20 chromium alloy and Inconel to have the best resistance of the materials tested. They also indicated that resistance of Inconel could be improved somewhat by increasing the chromium content of the alloy.

Subsequently corrosion tests were made in a full sized operating column during 1650 hours operation with the results reported<sup>6</sup> in Table XVI. The materials tested included low-carbon Type 316 stainless (0.03% max. carbon), "L" nickel, 80 nickel-20 chromium alloy, and Inconel of several different chromium contents. Welded specimens were included as well as beam-type stress corrosion specimens. Examination of these specimens after test showed no

susceptibility of any of the materials to stress corrosion cracking under these operating conditions and no accelerated attack at or adjacent to welds. Comparison of corrosion rates for Inconel alloys containing 13.6% chromium and 16.4% chromium shows the higher chromium content to have some beneficial effect upon corrosion resistance.

It is apparent that the corrosion resistance of all of the materials tested, with the exception of "L" nickel, is good enough that any one of them can be expected to give satisfactory equipment life. In practice, the selection of materials has been based upon a number of factors in addition to corrosion resistance. The 80 nickel-20 chromium alloy is not readily available in the forms required. Consequently, the fat splitting towers built to date have used either Inconel or Type 316 stainless for corrosion resisting surfaces. Several towers have been built of Lukens Inconel-clad steel and at least two towers of Smith "layer-built" construction with Inconel liner. Principal factors governing the choice of Inconel for these types of construction were the fact that the coefficient of thermal expansion of this alloy is very close to that of steel (the towers are approximately 65 feet

TABLE XVII—Plant Corrosion Tests in Distillation of Fatty Acids in Vacuum Batch Stills

Crude fatty acids charged to batch stills and distilled under vacuum with live steam injected at bottom of still. The number of batches run per week varies somewhat from one plant to another. In these tests the stills were run most of

the time. Tests made in both liquid and vapor phases. Temperature 225-270° C. (440-520° F.). Duration of tests as noted below.

Material	CORROSION RATE, INCH PER YEAR*								
	Test 1a, 21 Days		Test 2b, 51 Days In Vapor	Test 3, 77 Days In Liquid	Test 4c, 22 Days		Test 5d, 210 Days In Vapor	Test 6e, 42 Days	
	In Vapor	In Liquid			In Vapor	In Liquid		In Vapor	In Liquid
Inconel.....	0.0008	0.0011	0.0018	0.0001	0.0016	0.0036	0.0003	0.0001	0.0004
Nickel.....	0.0033	0.0041	0.012	0.0092	0.014	0.014	0.0053	0.0078	0.012
Monel.....	0.0025	0.0039	0.010	0.012	0.014	0.026	0.0056	0.0083	0.018
Aluminum 3S.....	.....	.....	0.0009e	.....	0.0003	x	x	.....	.....
Copper.....	0.0040	0.0046	.....	.....	.....	.....	.....	.....	.....
18-8 Stainless, (Type 304).....	0.014	0.019	0.038	0.0014	.....	.....	0.0016f	0.010	0.0035
18-8 Mo Stainless, (Type 316).....	.....	.....	0.0001	.....	.....	.....	0.0001	0.0001	0.0002
18-8 Mo Stainless, (Type 317).....	.....	.....	.....	.....	.....	.....	.....	.....	0.0002
Hastelloy C.....	.....	.....	.....	.....	.....	.....	.....	0.0001	0.0001
Ni-Resist (Type 1).....	0.014	0.015	0.017	0.018	0.026	0.061	0.013	0.034	0.042
Cast Iron.....	0.73	0.79	0.43	0.37	0.85	1.19	z	0.49	0.42
Mild Steel.....	0.098	0.14	y	y	.....	.....	y	.....	.....

a—Fatty acids from animal tallow.

b—Fatty acids from cottonseed oil.

c—Fatty acids from animal and vegetable oils.

d—Fatty acids from fish oils.

e—Tests 1, 2, 3 and 4 from Reference 1.

e—Pitted to maximum depth of 0.006 inch.

f—Pitted to maximum depth of 0.003 inch.

x—Corroded entirely away. Original thickness 0.032 inch.

y—Corroded entirely away. Original thickness 0.062 inch.

z—Corroded entirely away. Original thickness 0.187 inch.

TABLE XVIII—Plant Corrosion Tests in Continuous Fatty Acid Vacuum Bubble Tower<sup>1</sup>

Test 1: Immersed in liquid fatty acid stream in outlet head of fatty acid pre-heater. Temperature 245° C. (475° F.). Duration of test 147 days.

Tests 2 to 6: In distilling tower at various locations. Temperature from 220°

C. (425° F.) at top of column to 275° C. (525° F.) at bottom. Duration of test 84 days during processing of 3,203,000 lb. of crude fatty acids from tallow.

Material	Corrosion Rate, Inch per Year					
	Test 1 Pre-heater	Test 2 Between Tray 1 & Screen (Bottom)	Test 3 Between Tray 1 & Tray 2 (Feed)	Test 4 Between Tray 2 & Tray 3 (Feed)	Test 5 Between Tray 3 & Tray 4	Test 6 Between Tray 4 & Tray 5 (Top)
Inconel.....	0.0003	0.0014	0.0016	0.0003	0.0002	<0.0001
Nickel.....	0.016	0.0041	0.0033	0.0031	0.0033	0.0021
Monel.....	0.023	0.0027	0.0042	0.0041	0.0043	0.0027
Aluminum 3S.....	0.0003a	0.0051	0.0023	0.013	0.0052	0.0084
Copper.....	0.0027	0.0049	0.0058	0.0058	0.0045	0.0051
18-8 Stainless (Type 304).....	0.013b	0.0044	0.0076	0.0079	0.0070	0.0001
18-8 Mo Stainless (Type 316).....	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Ni-Resist (Type 1).....	.....	0.024	0.031	0.029	0.020	0.015
Cast Iron.....	.....	x	x	x	x	0.18c

a—Pitted to maximum depth of 0.003 inch.

b—Perforated by pitting. Original thickness 0.032 inch.

c—Almost completely graphitized. Original thickness 0.187 inch.

x—Destroyed by graphitization. Original thickness 0.187 inch.

<—Less than.

**TABLE XIX—Plant Corrosion Tests in Continuous Deodorization and Distillation of Animal Fatty Acids in Vacuum Bubble Towers**  
(Duration of Tests—3900 Hours Operation)

**Test 1:** In vapor and liquid spray of light fatty acid fractions plus about 10% stripping steam on top tray of deodorizer column above bubble caps. Temperature 150-175° C. (300-350° F.).

**Test 2:** In liquid fatty acids about 99% concentration, stripped of light fractions, at bottom of surge tank between deodorizer and distillation column. Temperature 150-175° C. (300-350° F.).

**Test 3:** In vapor and liquid, about 99% fatty acid concentration plus about 20% by weight of stripping steam above top tray of column near inlet of preheated liquid. Temperature 205-225° C. (400-440° F.).

**Test 4:** In liquid containing 40% free fatty acids and 60% "pitch" at bottom of column near liquid outlet. Temperature 205-240° C. (400-460° F.).

Material	Corrosion Rate, Inch per Year <sup>a</sup>			
	Test 1	Test 2	Test 3	Test 4
Inconel Sheet	<0.0001	<0.0001	0.0001	<0.0001
Inconel Sheet (Welded)	<0.0001	<0.0001	0.0001	<0.0001
Nickel Sheet	0.0046	0.0062	0.017	0.0043
Monel Sheet	0.0020	0.0054	0.016	0.0032
18-8 (Type 302) Stainless Sheet	<0.0001	<0.0001	0.0005	<0.0001
18-8 (Type 304) Stainless Sheet	<0.0001	<0.0001	0.0003	0.0001
18-8 (Type 304) Stainless Plate (Welded, as-welded)	<0.0001	0.0001	0.0027	0.0004
18-8 (Type 304) Stainless Plate (Welded, Annealed)	0.0001			
18-8 Cb (Type 347) Stainless Sheet	<0.0001	<0.0001	<0.0001	0.0001
18-8 Cb (Type 347) Stainless Plate (Welded, as-welded)	<0.0001	<0.0001	0.0009	0.0001
18-8 Mo (Type 316) Stainless Sheet	<0.0001	<0.0001	<0.0001	<0.0001
18-8 Mo (Type 316) Stainless Plate (Welded, as-welded)	<0.0001	0.0001	<0.0001	0.0001
18-8 Mo (Type 316) Stainless Plate (Welded, Annealed)	<0.0001	<0.0001	<0.0001	0.0001
Ni-Resist (Type 1)	0.0044	0.0058	0.015	0.0085
Cast Iron	0.087	0.037	x	x

<—Less than.

x—Corroded completely away. Original thickness 0.187 inch.

a—There was no evidence of accelerated corrosion in heat-affected areas of any welded specimens. There was no pitting attack on any specimens.

**TABLE XX**  
**Plant Corrosion Tests in Distillation of Fatty Acids From Vegetable Oils in High-Vacuum Molecular Still**

**Test 1:** In mixed stearic and palmitic acid vapors in top of still. Temperature 104-125° C (220-260° F). Duration of test 32 days.

**Test 2:** Alternately exposed to stripped vegetable oils (acid value range 85-95) and to fatty acid vapor in bottom of still. Temperature 180-200° C (355-390° F). Duration of test 23 days.

Material	Corrosion Rate, Inch per Year	
	Test 1	Test 2
Monel	0.0009	0.0054
Nickel	0.0010	0.0035
Inconel	<0.0001	0.0001
18-8 Stainless (Type 304)	<0.0001	0.0001
18-8 Mo Stainless (Type 316)	<0.0001	0.0001
Ni-Resist (Type 1)	0.0005	0.0077
Mild Steel	0.010	0.041

<—Less than.

**TABLE XXI**  
**Corrosion Tests in High Vacuum Fractionating Column During Distillation of Light-Odor Fractions of Refined Tall Oil**

Tests made in vapor at top of column. Water vapor from tall oil also present. Temperature 100° C (210° F).

Duration of Tests 195 Days

Material	Corrosion Rate, Inch per Year	
	Test 1	Test 2
Monel		0.0010
Nickel		0.0007
Inconel		0.0001
18-8 Stainless (Type 304)		0.0001a
18-8 Mo Stainless (Type 316)		0.0001
25 Cr—20 Ni Stainless (Type 319)		0.0001
35 Ni—15 Cr Stainless (Type 337)		0.0001
13 Cr Steel (Type 403)		0.0005
Hastelloy C		0.0001
Copper		0.0030
Mild Steel		0.0034
Ni-Resist (Type 1)		0.0009
Cast Iron		0.0025

a—Pitted to maximum depth of .004 inch.

tall) in the operating temperature range, and the fact that welded Inconel does not require heat treatment to maintain corrosion resistance. Several towers have been constructed of solid Type 316 stainless plate. It is understood that at least part of these towers were annealed after fabrication. One tower recently has been constructed of steel with a lining of extra low carbon Type 316 stainless (0.03% C max.) sheet applied by spot welding.

#### Distillation of Fatty Acids

Corrosion testing in fatty acid stills started a good many years ago when practically all distillation was carried out in batch kettles frequently made of cast iron. The results of a number of the spool tests in batch stills are given in Table XVII. The amount of vacuum and hence the temperature of the fatty acids varied somewhat from one still to the other but came within the range of about 440-520° F. In some cases, tests were made in both the liquid and vapor phases in the same vessel. Such tests indicate that the liquid phase is generally somewhat more corrosive than the vapor. The corrosion rates of cast iron in these tests appear to be higher than the rates usually obtained in cast iron stills. Most of the test samples were severely graphitized (in one case with samples 3/16" thick there was nothing left but carbon). These samples were of course corroded from both sides in test. It seems probable that in actual stills a graphitized layer formed which in some cases became filled with organic material to the extent that it tended to protect the underlying cast iron from rapid attack.

When plate and cap columns were adapted to the continuous distillation of fatty acids, the choice of materials for their construction was based largely upon the previous tests in batch stills. Then corro-



sion tests were made at various levels in the continuous towers. The results of one such series of tests are given in Table XVIII. This table also includes the results of tests made in the outlet head of a tubular fatty acid preheater attached to this equipment.

Type 316 stainless and Inconel are shown by these test results to be the most resistant materials under distillation conditions and both of these alloys have been used in the construction of distillation equipment with satisfactory performance. A column fabricated of solid Inconel with bubble plates and caps has been in operation for approximately 14 years and columns of Type 316 stainless have been in use practically as long. While Type 316 stainless sometimes shows slightly lower corrosion rates than Inconel in the tests made in the columns themselves at fatty acid temperatures up to about 525° F, experience has shown that Inconel usually is more corrosion resistant than this stainless alloy at the higher temperatures encountered in the tubes of fatty acid preheaters commonly heated with Dowtherm at about 650° F.

In Table XIX are given the results of a series of corrosion tests made in continuous distillation equipment in another plant for the primary purpose of testing welded specimens of the stainless steels. All of these welded test specimens of stainless steels were made by welding together strips of 1/4-inch

thick plate and machining specimens to a rectangular size of about 2 inches by 3 inches with two 2-inch long welds in each sample. Analyses of the stainless plate used in making the welded specimens were as follows:

	% Cr	% Ni	% Mo	% C	% Cb
Type 304	19.17	9.48	...	.08	...
Type 347	18.51	10.60	...	.09	1.12
Type 316	17.15	10.90	2.20	.07	...

Some of the welded specimens of each type of stainless were left in the as-welded condition without heat treatment and part of them were annealed at about 2000° F, water quenched, and pickled. In no case was any evidence found of accelerated attack adjacent to welds in the as-welded specimens of stainless steels in these tests. It should be pointed out that the operating temperatures in this distillation column appear to be somewhat lower than those sometimes encountered, which may account for the satisfactory general corrosion resistance of Types 304 and 347 stainless. These alloys do not usually have such good resistance as indicated by the test results in Tables XVII and XVIII. Several users of Type 316 stainless distillation equipment consulted reported a number of their units were not heat treated in any way after fabrication. In none of these cases has there been any apparent trouble from corrosion of heat affected areas adjacent to welds so it must be concluded that this alloy, at least with normal carbon contents, is not subject to attack resulting from weld sensitization in fatty acids at temperatures usually encountered in vacuum distillation. It should be pointed out that this also is true of Inconel distillation equipment, none of which has been heat treated after fabrication.

As a matter of interest, included in Table XX are the results of corrosion tests made during the stripping of fatty acids from vegetable oils in a very high vacuum molecular still. The principal purpose of these data is to indicate the performance of several metals and alloys in fatty acids at intermediate temperatures.

#### Tall Oil Distillation

Tall oil derived from the splitting of soaps formed in sulfate pulp mill black liquors is being used to some extent as a source of fatty acids. Tall oil is composed of approximately 30 to 45 percent fatty acids (mainly oleic, linoleic and linolic), 50 to 55 percent resin acids (mainly abietic) and 8 to 10 percent of unsaponifiable materials (mainly sterols). One method used for separating refined tall oil into its principal constituents is by fractional distillation under vacuum. In one plant, this was being done in the same equipment previously used for distillation of tallow fatty acids and advantage was taken of the opportunity to make corrosion tests during an operating period of 195 days. The results of these tests are shown in Tables XXI and XXII. The data in Table XXI were obtained in a deodorizing column operating at a relatively low temperature of 210° F so that none of the materials tested corroded very badly. However, in Table XXII, it is apparent that

TABLE XXII  
Corrosion Tests in High Vacuum Fractionation Column During  
Distillation of Refined Tall Oil

Duration of Tests 195 Days

Test 1: In vapor at top of column. Temperature 245-265° C (470-510° F).

Test 2: In liquid at bottom of column. Temperature 260-290° C (500-550° F).

Material	Corrosion Rate, Inch per Year	
	Test 1	Test 2
Monel	0.004	0.008
Nickel	0.003	0.015
Inconel	0.004	0.010
18-8 Stainless (Type 304)	x	x
18-8 Mo Stainless (Type 316)	0.0001	0.014
25 Cr-20 Ni Stainless (Type 310)	x	x
35 Ni-15 Cr Stainless (Type 330)	0.018	x
13 Cr Steel (Type 410)	x	x
Hastelloy C	<0.0001	<0.0001
Copper	x	x
Mild Steel	y	y
Ni-Resist (Type 1)	0.007a	0.030
Cast Iron	z	0.13b

x—Completely corroded away. Specimens originally .032 inch thick.  
y—Completely corroded away. Specimens originally .062 inch thick.  
z—Completely corroded away. Specimens originally .250 inch thick.  
a—Graphitized—some graphite not removed in cleaning.  
b—One specimen .250 inch thick completely corroded away.  
c—Less than.

TABLE XXIII  
Laboratory Corrosion Tests in Refined Tall Oil  
at Various Temperatures

Material	Corrosion Rate, Inch per Year			
	At 285° C (545° F)	At 300° C (572° F)	At 315° C (600° F)	At 330° C (625° F)
Type 302 Stainless	0.175	0.50	0.80	.....
Type 316 Stainless (2.20% Mo)	0.004	0.004	0.072	.....
Type 316 Stainless (2.33% Mo)	0.001	0.003	0.027	0.50
Type 316 Stainless (2.55% Mo)	0.002	0.002	0.059	.....
Type 317 Stainless (3.25% Mo)	0.0005	0.0008	0.021	.....
Inconel	0.010	0.010	0.013	0.011
Hastelloy C	0.004	0.005	0.004	.....

TABLE XXIV—Plant Corrosion Tests in Sulfuric Acid Washing of Fats and Fatty Acids

**Test 1:** Immersed during washing of tallow with 2% by weight of 60° Bé sulfuric acid. The water layer which separates after one hour contains 11 to 16% H<sub>2</sub>SO<sub>4</sub> by weight. Duration of test 12½ days (30 batches of 8 to 12 hour each). Agitated with live steam. Temperature approximately 121° C. (250° F.) during boiling.

**Test 2:** At liquid level during washing of margarine stock with 0.75% sulfuric acid water. Boiled for 10-30 minutes per batch and allowed to settle over night. 160,000 lb. of stock washed. Duration of test 38 days.<sup>1</sup>

**Test 3:** At liquid level during washing of oleic acid (red oil) with 0.75% sulfuric

acid water. Boiled for 5-10 minutes per batch and allowed to settle for 2 days. 196,000 lb. oil washed in 6 batches. Duration of test 38 days.<sup>1</sup>

**Test 4:** Immersed during washing of oleic acid with 1½% by wt. of 60° Bé sulfuric acid diluted with water to give concentration of 4 to 5% H<sub>2</sub>SO<sub>4</sub> in settled acid layer. Heated with closed steam coil. Agitated with air. Temperature approximately 100° C. (212° F.). Duration of test 12 days (26 batches of 10 to 12 hr. each).

**Test 5:** In sulfuric acid sludge from washing of fatty acids. Temperature atmospheric. Duration of tests 42 days. a—Immersed in sludge tank. b—At liquid level.

Material	Corrosion Rate, Inch per Year					
	Test 1	Test 2	Test 3	Test 4	Test 5a	Test 5b
Monel.....	0.0070	0.0012	0.0004	0.020	0.0021	0.0026
Nickel.....	0.013	0.0012	0.0012	0.034	0.0046	0.0055
Inconel.....	0.012	0.0009	0.0003	0.029	0.0055	0.0054
Copper.....	0.0040	0.0040	0.0010	0.035	.....	.....
Chemical Lead.....	0.0046	.....	.....	0.091	0.015	0.015
Aluminum 2S.....	.....	0.15	0.043	.....	.....	.....
Ni-Resist (Type 1).....	0.040	0.0040	0.0014	0.038	.....	.....
Cast Iron.....	.....	0.20	0.0032	.....	.....	.....
18-8 Stainless (Type 304).....	0.19	0.0001	0.0001	0.0002	.....	.....
18-8 Mo Stainless (Type 316).....	x	.....	.....	0.0001	0.024	0.041
17-19 Cr Stainless (Type 430).....	.....	.....	.....	0.16	.....	.....

x—Corroded away. Original thickness of specimens 0.032 inch.

TABLE XXIV (Continued)—Plant Corrosion Tests in Sulfuric Acid Washing of Fats and Fatty Acids

**Test 6:** Commercial stearic acid washed with 0.5% by weight of 60° Bé sulfuric acid. Total charge per batch approx. 12,000 lb. Boiled with live steam. Temperature 80-100° C. (180-210° F.). Duration of tests 35 days. a—Immersed near bottom of tank. b—Near liquid level at top of tank.

**Test 7:** Commercial stearic acid washed with 15% sulfuric acid solution during 34 batches. Boiled with live steam 45 minutes per batch or 25 hours during tests. Remainder of time settling. Total duration of tests 57 days. Average temperature during boiling 102° C. (215° F.). Cooled to room

temperature during settling. a—Immersed at bottom of tank. b—Immersed about half-way down in tank.

**Test 8:** Immersed during washing of fatty acids with concentrated sulfuric acid and dilution with water to give concentration of 5% H<sub>2</sub>SO<sub>4</sub> in acid layer. Subsequently washed with alkali. Heated with closed steam coil. Agitated with air. Temperature 104°-116° C. (220-240° F.). Duration of test 30 days.

Material	Corrosion Rate, Inch per Year				
	Test 6a	Test 6b	Test 7a	Test 7b	Test 8
Monel.....	0.0012	0.0011	0.0062	0.0027	0.0060
Nickel.....	0.0031	0.0032	0.0055a	0.0044	.....
Inconel.....	0.0004	0.0004	0.010b	0.0023	.....
Copper.....	0.0020	0.0019	.....	.....	.....
Chemical Lead.....	0.013	0.015	.....	.....	.....
18-8 Stainless (Type 304).....	0.0001	0.0001	0.023	0.0010	.....
18-8 Mo Stainless (Type 316).....	0.0001	0.0001	0.0003	0.0002	.....
25 Cr—20 Ni Stainless (Type 310).....	.....	.....	.....	.....	0.044
25 Cr—12 Ni Stainless (Type 309).....	.....	.....	.....	.....	0.012
20 Cr—25 Ni Stainless (Type 311).....	.....	.....	.....	.....	0.024
35 Ni—15 Cr Stainless (Type 330).....	.....	.....	.....	.....	0.037
Illum R.....	.....	.....	.....	.....	0.0060
Durimet 20.....	.....	.....	.....	.....	0.0050
Pioneer Metal.....	.....	.....	.....	.....	0.0010
Hastelloy C.....	.....	.....	.....	.....	0.0020

a—Pitted to maximum depth of 0.014 inch.

b—Pitted to maximum depth of 0.005 inch.

corrosive conditions during the distillation of refined tall oil are more severe than in the other fatty acid distillations reported. It is believed this chiefly is a consequence of the higher temperature levels employed, although tall oil possibly may be somewhat more corrosive than the straight fatty acid mixtures at the same temperatures.

It is interesting to note that at the bottom of the column where liquid temperatures were as high as 550° F, the corrosion rate of Type 316 stainless steel was significantly higher than in the top of the column at about 500° F. The user noted that in the pre-heater to this column, Inconel tubes appeared to give considerably better performance than Type 316 stainless tubes. This led the user to make the laboratory corrosion tests which are reported in Table XXIII.<sup>7</sup> Specimens of the various alloys were tested in refined

tall oil at the several temperatures from 545° F to 625° F. It will be noted that the corrosion rate of Inconel remains substantially the same throughout this temperature range, whereas the corrosion rates of Type 316 and Type 317 stainless increase considerably at temperatures above 575° F.

#### Acid Washing of Fatty Acids

Both oleic acid and stearic acid frequently are washed with sulfuric acid after distillation in order to improve color. A considerable number of plant corrosion tests have been made in acid washing tanks and the results of these tests are summarized in Table XXIV. Monel and lead are the metallic materials most commonly used for construction of acid washing tanks and for steam heating coils and accessories. It should be noted that Monel may be subject

to accelerated attack if the mixture is agitated with air during acid washing and this practice should be discouraged where this alloy is used. Test 4 was made with air-agitation and comparison with other tests shows a ten-fold increase in corrosion. Test 8 also was made with air agitation but in this case the acid temperature was so high (220-240° F) that air had very little solubility in the acid. Agitation with steam only does not appear to increase corrosion to any marked extent.

Type 316 stainless steel showed good corrosion resistance in some of the tests in Table XXIV where temperatures did not exceed about 215° F. However, where significantly higher temperatures are encountered, this alloy may be subject to considerable attack in sulfuric acid solutions as indicated by Test 1 which was made during the acid washing of tallow at temperatures up to 250° F. It is possible that Type 316 stainless or Inconel equipment might be applied to the acid washing of the highest grade stearic acid if small amounts of copper salts from Monel are considered to have any effect upon the color of this product. If stainless steel equipment is to be welded, the extra-low carbon variety of Type 316 (.03 max. carbon) would be preferred. The satisfactory use of Inconel has been recorded for a perforated steam sparging pipe in acid washing of stearic acid.

### Fatty Acid Storage

Several tests have been made in the storage of fatty acids as recorded in Table XXV. Aluminum commonly is used for storage of the refined products. In some cases, stainless-clad and Inconel-clad tanks also are used. Here again the problem is chiefly one of preventing discoloration by objectionable metallic pick-up.

As further developments occur in the processing of soaps and fatty acids, additional plant corrosion tests will be made in order to assist plant engineers to properly evaluate the various construction materials available to them. For assistance in making the corrosion tests reported in this paper, the authors are indebted to the operating personnel of the various plants in which the tests were made.

### References

1. G. L. Cox, *Ind. Eng. Chem.*, **30**, 1349-55 (1938).
2. ASTM Standards, Part I-A, 491-99 (1946).
3. Anon. *Chem. Eng. Prog.*, **44**, No. 10, 16-18 (1948).
4. G. W. McBride, *Chem. Eng.*, **55**, No. 10, 94-97 (1947).
5. H. L. Barnebey and A. C. Brown, *J. Am. Oil Chemists Soc.*, **25**, 95-99 (1948).
6. Communication from A. O. Smith Corp. (1948).
7. Private communication (1945).

TABLE XXV—Plant Corrosion Tests in Storage of Fatty Acids

Test 1: In storage of crude mixed fatty acids after splitting. Temperature 70-82° C. (160-180° F.). Duration of tests 61 days. a—Immersed in liquid. b—At liquid level.

Test 2: Immersed in storage of concentrated mixed fatty acids from fish oils. Temperature 70-120° C. (160-250° F.). Duration of test 130 days.

Test 3: Immersed in storage of a compounded fatty acid with acid number 170. Average temperature 65° C. (150° F.). Duration of test 122 days. Tank emptied and filled as required.

Test 4: Immersed in feed tank in crude vegetable oils with acid number 105-120. Acids principally stearic and palmitic. Temperature 26-83° C. (80-185° F.). Duration of test 62 days. Periodic recirculation of oils.

Test 5: Immersed in storage of mixed fatty acids neutralized with 1 lb. soda ash per 1,000 lb. stock. Temperature: Stock in 38° C. (100° F.). Stock out 120° C. (250° F.). Duration of test 14 days. Tank filled and emptied every 4 hours.

Material	Corrosion Rate, Inch per Year					
	Test 1a	Test 1b	Test 2	Test 3	Test 4	Test 5
Monel	0.0004	0.0003	0.0018	0.0004	0.0002	0.0002
Nickel	0.0015	0.0018	0.0029	0.0010	0.0003	0.0004
Inconel	<0.0001	<0.0001	<0.0001	0.0001	0.0001	<0.0001
Copper	0.0005	0.0005	.....	.....	.....	0.0005
Cast Bronze	0.0010	0.0008	.....	.....	.....	.....
Aluminum 2S	0.0009	0.0008	0.0039	.....	.....	.....
Chemical Lead	0.0008	0.012	.....	.....	.....	0.0051
18-8 Stainless (Type 302)	<0.0001	0.0001	<0.0001	0.0001	<0.0001	<0.0001
18-8 Stainless (Type 304)	<0.0001	0.0001	<0.0001	0.0001	<0.0000	<0.0001
18-8 Mo Stainless (Type 316)	.....	.....	<0.0001	<0.0001	<0.0001	<0.0001
17-19 Cr Steel (Type 430)	<0.0001	.....	.....	0.0002	.....	.....
Ni-Resist (Type 1)	.....	.....	0.0086	.....	<0.0001	0.0005
Cast Iron	.....	.....	0.064	.....	.....	0.0054
Mild Steel	.....	.....	0.0070	.....	0.0027	0.0023

<—Less than.

### DISCUSSION

Questions by John L. McPherson, Chemical Plants Div. of Blaw-Knox Corp., 321 Penn Ave, Pittsburgh, Pa.:

Mr. Friend is to be congratulated for his presentation of the results of corrosion tests conducted in Soap and Fatty Acid Processing Plants.

1. Mention was made of one soap company using nickel plated carbon steel pipe to resist corrosion in soap processing. I would like to know the thickness

of the nickel coating and if the coating was tested for porosity. Mostly thinly-plated nickel surfaces are somewhat porous and unless some method of protection against porosity is used, corrosion at the pore may result. This is especially true in handling corrosives where galvanic action may occur.

2. Also, I noticed that the low carbon Type 316 stainless steel specimens used for the fatty acid corrosion test were stress relieved at about 1050° F. The



majority of the states in this country require high pressure fat splitting columns to be fabricated in accordance with Section VIII of the ASME Boiler Construction Code. These rules require Type 316 stainless clad carbon steel vessels to be stress relieved at a minimum temperature of 1100° F. Low temperature stress relieving is being considered by the Boiler Code Committee, but is not at present permitted under this Code.

I would like to know if corrosion tests have been made after stress relieving 0.03 maximum carbon Type 316 stainless steel at 1100 to 1200° F, and if so, was there any difference in corrosion rate?

#### Replies by W. Z. Friend:

1. The original thickness of nickel plating inside the pipe was .007 to .008 inch which is generally standard for this type of piping. The nickel plating was tested for porosity by two different test methods. One test consisted in immersing a section of pipe in hot water saturated with carbon dioxide and with slightly acid pH at 200° F. In this test, if any pores are present, they will show brown stains within four hours. No such stains were evident on the nickel surface. In the other test, a salt solution containing potassium ferrocyanide is applied to the nickel surface. In this test, blue spots will appear if pores are present. No such spots were apparent. Experience has shown that properly applied electrolytic nickel

plating of .003 inch thickness or greater can be depended upon to be free from porosity.

2. Mr. M. A. Scheil of A. O. Smith Corp. was connected with these tests and I will ask him to reply to your question.

#### Replies by M. A. Scheil, A. O. Smith Corp., Milwaukee, Wis.:

1. Under a special interpretation of the ASME Boiler Construction Code vessels with applied liners are being stress annealed at a minimum temperature of 1000° F for three hours per inch of carbon steel backing.

2. Table 16 of the Inco paper shows plant corrosion tests in continuous counter-current fat splitting tower. The heat treatment of this material is as follows:

Test Program No. 1—The low carbon Type 316, the Inconel with 13.6 percent Cr and the 'L' nickel all were heat treated after welding at 1150° F for 1½ hours.

Test Program No. 2—The low carbon Type 316 after welding was heat treated at 1000° F for 2 hours.

The Inconel with 17.9 percent Cr had no heat treatment. It was not welded and was exposed in the as-received condition.

Both 80Ni-20Cr specimens were welded and received 1175° F for 1½ hours.

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# Experience and Economic Benefits From Cathodic Protection on Gas Distribution Systems\*

By A. W. PEABODY and C. L. WOODY

## Introduction

THIS PAPER pertains to the practical cathodic protection experience and the economic benefits received from cathodic protection by two companies. One is a Mid-South combination gas and electric utility, the other a Southern gas distribution company. Throughout the paper, these companies will be referred to as the combination company and the gas company. Collectively, the companies serve natural gas to 236 cities and towns through approximately 5200 miles of 3-inch equivalent steel mains (in addition to cast iron mains), with over 382,000 customers. The majority of the gas distribution systems lies in areas where corrosive soils are the rule rather than the exception. Corrosion of mains and services long has been a serious problem—leading to early investigation of the possible advantages of cathodic protection. Initial investigations were made as early as 1935 but first permanent installations were engineered and installed in 1941. Since 1941, cathodic protection has been installed progressively until at present approximately 42 percent of all steel mains are under protection by the combination company and 7 percent by the gas company.

## Leaks Reduced by Cathodic Protection

The nature of cathodic protection is such that an extended period of time often passes before success or failure of an installation may be judged. For this reason, a report on some of the earlier installations will have the greatest weight. First, two installations by the combination company will be described, one on an old and corroding section of an existing system, and the other on an entire small distribution system (96 services) which was protected very soon after completion.

The first installation mentioned consisted of application of cathodic protection to a 1.2-mile section of a 12-inch steel belt line on a city distribution system. In 1941, this line was eleven years old, had an enamel protective coating without wrapper and was developing leaks so rapidly extensive replacements were contemplated. As an alternative, it was decided to apply cathodic protection. This section has been protected since 1941 with two small rectifier units. During the years since, no further serious corrosion difficulties have been experienced. The remaining 3.4 miles of this 12-inch belt line were placed under cathodic protection in 1942 and 1943.

The most recent detailed inspection on this 12-inch line was made in 1948 on a 4000-foot section which in January of 1941 had 18 leaks. Pipe inspections made in this area in 1941 revealed that corrosion was very severe, indicating early replacement of about



CHARLES L. WOODY

Corrosion engineer with the operating division of United Gas Corp., Houston, Texas, he holds an electrical engineering degree from North Carolina State College, was engineer assigned to underground corrosion mitigation for Ebasco Services 1946-49, Army Signal Corps 1943-46, meter engineer in charge of precision metering, Carolina Power and Light Co. and Mississippi Power and Light Co. 1938-43.



A. W. PEABODY

Electrical engineer with Ebasco Services, N. Y., is a graduate of the University of Maine. Since 1939, with exception of 4½ years in Army Signal Corps he has been engaged in corrosion and electrolysis prevention and design of cathodic protection equipment for the protection of underground pipelines and cables.

\*A paper presented at the Fifth Annual Conference of The National Association of Corrosion Engineers at Cincinnati, Ohio, April 11-14, 1949.

1500 feet of pipe would be necessary if protection was not applied. In 1948, after nearly six years of cathodic protection, a detailed leak survey was made on this section prior to installation of concrete paving over the line by the city. Only two corrosion leaks were found on the 12-inch main in this section. These were the only ones which had developed since the repair of those found in 1941. These leaks were in areas found badly corroded in 1941 and 1942 and it is believed they were due to pressure increase in the last few years which may have caused the perforation of deep pits existing when protection was applied. If this line had been allowed to corrode freely during this past six years, it is estimated nearly 150 leaks would have occurred. This is in conformity with the expected progressive increase in rate of occurrence of leaks on a corroding line. This in itself would have resulted in costly leak repairs, increase in unaccounted-for gas losses, and probable main replacements. It is estimated it would have cost at least \$10,500 to replace 1500 feet of main in this area.

The other cathodic protection installation made in 1941 by the combination company was on an entire distribution system less than a year old. This all-steel system was coated with coal tar enamel and asbestos wrapper. All mains and services were placed under cathodic protection in 1941. During the last seven years, one corrosion leak has occurred on this system. Upon investigating this leak, a service failure, it was found this particular service was not tied in to the cathodic protection system because of accidental insulation at a coupling which had been left unbonded. This failure of unprotected pipe was fortunate in that it helped to substantiate the benefits obtained from cathodic protection. All other services and mains in the system are receiving protection and wherever they have been bared, the pipe is in new condition with no evidence of corrosion. The original single cathodic protection unit has served since 1941 even though there has been considerable expansion of the system (from 3.22 to 5.78 miles of 3-inch equivalent) plus addition of approximately 2600 feet of bare service pipe made necessary by war scarcities.

A third installation, by the gas company, was made in 1941 on a 12,200-foot section of 6-inch high pressure gas distribution feeder which, in 1941, was ten years old with a record of 13 leaks. Of the 12,000 feet of line, 2000 is bare, 6000 is grease coated, and 4200 is enamel coated. As an alternate to replacing 4000 feet of the line, cathodic protection was applied with one 40-ampere rectifier which subsequent tests revealed was applying full protection to 9000 feet of the line with partial protection to the remainder. In the seven years since application of protection, only two leaks have developed. These two leaks occurred prior to 1947 on the part of the line which was not receiving full protection. In 1947, galvanic anodes were used to supplement the rectifier and furnish full protection to that part of the line which had not been getting sufficient current. No further leaks have developed. If protection had not been applied in 1941, it is estimated that nearly 150 leaks would have appeared by 1949 on the 12,200 feet of line.

Leak records of the gas company on 111 miles of

3-inch equivalent old steel pipe under protection show that 79 leaks developed during the year prior to application of cathodic protection. During the year after application of protection, 11 leaks appeared but in the following six months only 2 additional leaks developed.

Results such as these have convinced management of the practicability and desirability of cathodic protection.

### Saving in Pipe Cost Is Effected

Faith in cathodic protection has permitted the use, for mains and services, of thin-walled pipe and tubing as well as reconditioned used pipe. Elimination of the necessity for providing extra wall thickness to extend pipe life in corrosive soils has been a distinct advantage, tending in part to offset shortages of standard pipe. When buying new pipe, it is now the practice of both companies to buy lighter weight steel pipe in sizes over 2 inches. For example, 8.64-lb. 4-inch pipe now is specified by the combination company instead of 11.35-lb. pipe and 12.89-lb. 6-inch pipe is now specified instead of 18.97-lb. pipe. Cost saving is directly proportional to weight reduction. This amounts to a 23.8 percent saving on the 4-inch pipe and a 32 percent saving on the 6-inch pipe. The gas company is effecting reductions in weight and cost for all steel pipe from 2-inch to 16-inch to be used in protected systems. The reduction varies from 7 percent to 40 percent, with an average of approximately 20 percent.

### Cathodic Protection Systems Compared

Direct current requirements for cathodic protection on these systems are supplied by rectifier units and galvanic anode installations. At present, there are 63 rectifiers and 214 galvanic anode installations (totaling 45,800 pounds of zinc, 20,100 pounds of magnesium and 200 pounds of aluminum) protecting 588 miles of 3-inch equivalent steel main.

### Rectifier Units

Rectifier units are used extensively by the combination company where longer lengths of main are to be protected. Since this company markets both gas and electricity, the actual out-of-pocket cost of electricity for company use on the gas system is relatively low (1 cent per kwh average) as compared to the energy cost to the gas company where purchased at commercial retail rates (4 cents per kwh average).

In order to limit the amount of current introduced into the ground at any one point, relatively small rectifier units are used in congested locations. The standard rectifier employed by the combination company has a maximum capacity of nine amperes at twelve volts but is seldom loaded to that extent because installations are designed with reserve capacity to allow for main additions and new services in the section under protection as well as to allow for coating deterioration with time. Rectifiers used are built by company personnel as a rainy day project using a standard design established in 1941. Figure 1 represents the standard rectifier design and shows the



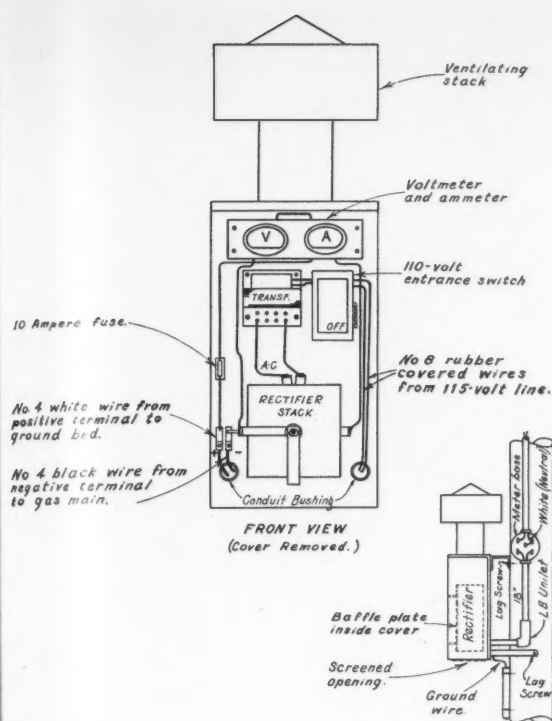


Figure 1—Standard design of rectifier units built in combination company shops.

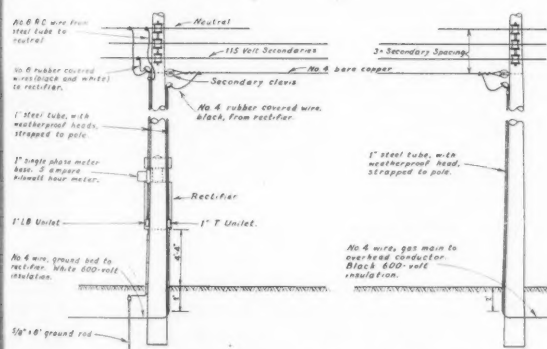


Figure 2—Sketch of typical rectifier installation.

manner in which the various elements are mounted as well as the means of providing adequate ventilation for the unit—an important factor in obtaining long operating life. Figure 2 shows the manner in which the rectifier is used in a typical installation. Performance of these units has been very satisfactory. Building the units in the company shops has been satisfactory from the standpoint of maintaining sufficient stocks of completed units to meet the requirements of new cathodic protection installations. These rectifiers cost less than \$100, complete.

Ground beds used with rectifier units are of several types. Many of the earlier installations have ground beds of scrap pipe or steel rail with steel pipe connecting headers. Such ground beds have served fairly well, and all but two still are in service. Most of the maintenance on these ground beds has involved re-

**INSTALLATION PROCEDURE:** Fill first 6" of augered hole with well-tamped coke breeze. Place anode in position and center. Backfill with well-tamped coke breeze until top of anode is covered by 6". Connect anode pigtail to header wire and insulate connection. Backfill to surface with dirt.

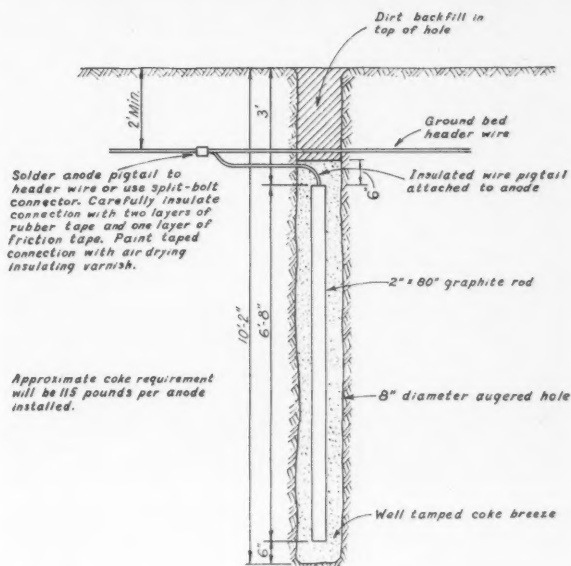


Figure 3—Installation specifications for a single ground bed anode.

Header wire, No 2 copper with 600-volt white insulation. Header wire should be buried two feet deep. Use caution to prevent cutting the insulation with shovels, etc.

Wire to rectifier, No 4 copper with 600-volt white insulation. Wire to rectifier should preferably tap header wire at midpoint as shown but may be at either end if closer to the rectifier.

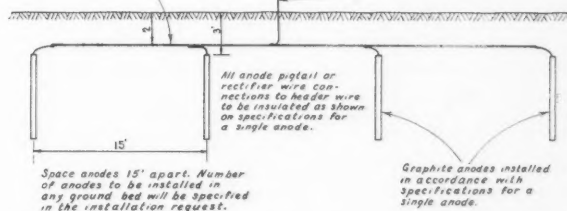


Figure 4—Manner of connecting several ground bed anodes in parallel.

pair of breaks in the headers. The two ground beds lost had been covered with concrete paving, making it impractical to replace defective headers. More recently, carbon or graphite anodes have been used for ground bed construction. For the past two years, an established standard construction calls for graphite anodes backfilled with coke breeze. Figure 3 details the installation specifications for a single ground bed anode while Figure 4 illustrates the manner in which several are connected in parallel for the standard type of ground bed construction now used. This type of construction simplifies engineering and construction in that all components are stocked as standard stores items and can be installed with a minimum of skilled labor. Further advantages are that the rate of consumption of the graphite anodes is about one-ninth that of steel, plus the tendency for part of the attack to be on the coke breeze backfill rather than on the graphite anode core. Long life is expected from this construction.



Figure 5—Typical rectifier installation. Positive ground lead runs overhead to pole in right background and down pole to ground bed header.

Figure 5 is a photograph of a typical complete rectifier installation showing external appearance of the unit and usual method of mounting. Figure 6 is a close-up photograph of the rectifier with cover open to show the internal arrangement of component parts.

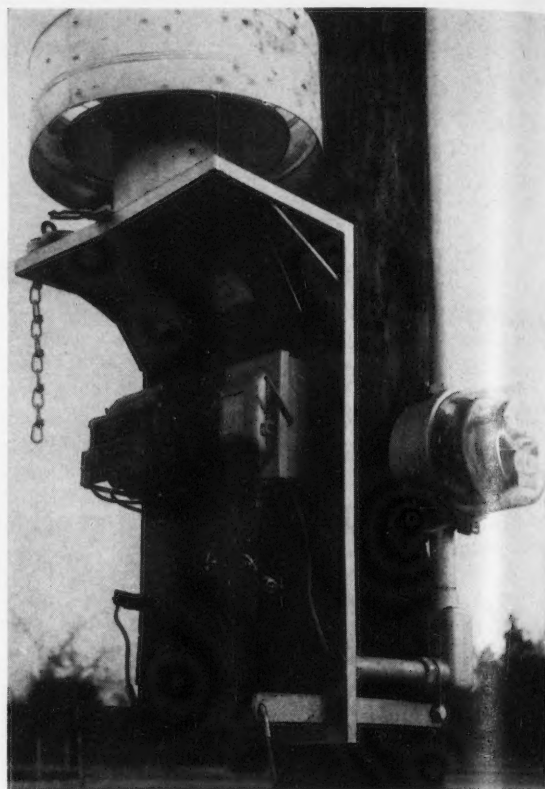


Figure 6—Typical rectifier unit.

#### Galvanic Anodes

The gas company has found that by using zinc or magnesium anodes it is possible to install galvanic anodes satisfactorily at practically all locations at which it is desirable to provide cathodic protection. The material used and the arrangement of the individual anodes is determined by the desired current output, soil resistivity, space available, and to some extent the chemical composition of the soil. It is the policy to make a complete investigation of the pipe line to be protected and the soil in the vicinity of the pipe line before the actual anode installation is designed. The anodes always are installed in permanently moist soil having low resistivity.

Current output per anode is controlled by spacing in a manner to limit whenever possible, individual anode currents by mutual reaction.

In some cases in which it is desirable to protect bare lines or uninsulated lines, it is necessary to distribute the anodes along the pipe line and limit anode currents when necessary by inserting resistors in the anode leads. In general, current output per anode is determined by the life expectancy desired from the anode installation. In the case of high resistance soils, the life expectancy is not a factor, because it is necessary to install a relatively large number of anodes in order to obtain desired current.

Whenever possible, the magnesium anode installations are adjusted for ten-year life. Zinc installations normally are adjusted for a twenty to thirty-year life

depending on the pipe line coating. In the case of a completely protected new distribution system, sufficient anodes usually are installed to give an initial apparent life expectancy of fifty years. It is anticipated that the overall life expectancy will be decreased because of normal aging of coating and new extensions.

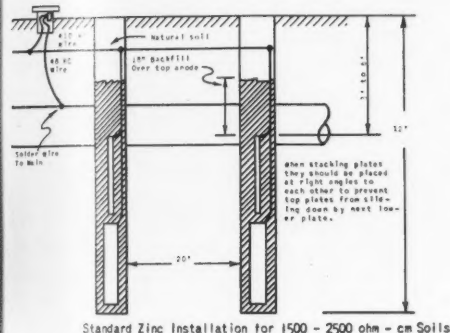
Both magnesium and zinc anodes are installed in augured holes, backfilled with a special backfill mixture. This mixture consists of 50 percent drilling clay and 50 percent gypsum molding plaster. The mixture may be bought ready mixed, or mixed on the job. The mixture may be used dry, or mixed with water and poured in the hole in the form of a slurry, depending on the local condition and equipment available.

Standard procedure for installing and connecting anodes has been set up so materials may be stocked readily at central supply points. In general, standard procedure is as indicated in Figures 7 and 8. This may be varied by increasing the depth of the holes and installing a larger number of anodes per hole. Under certain condition, the anodes may be installed in a horizontal position in the bottom of the ditch. Normally, space considerations in congested areas in which the gas company operates, prevents horizontal installations. While in general zinc and magnesium may be used interchangeably, it is standard practice to use zinc in soils below 2500 ohms cm when protecting new pipe. When it is necessary to install anodes in soils having resistivity greater than 2500

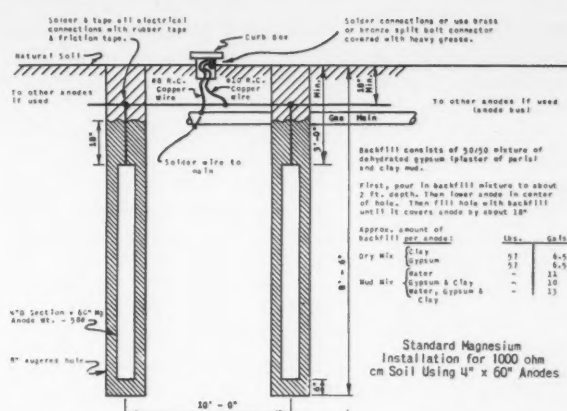
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**Figure 7—Standard procedure for installing zinc anodes.**



**Figure 8—Standard Procedure for installing magnesium anodes.**

towns 6 to 9 are those in which the cathodically protected system is enamel coated. Amounts of current required for protection are compared.

From the table, it can be seen there is a marked variation in amount of current collected per mile of 3-inch equivalent among the grease coated systems and the enamel coated systems alike, but that average current required to protect enamel coated systems is much lower than that for grease coated systems. Variations in current collected are caused by differences in adjustment of the individual systems, differences in quality of the pipe coating job or to differences in soil resistivity (although this last is more noticeable on grease coated systems).

Town No. 5, which takes the highest current, has uniformly low soil resistivity whereas the remaining

TABLE I

	Coating	Miles of 3" Equiv. Mains and Services	Protection	Total Current Amperes	Amperes per Mile of 3" Equiv.
Town 1.....	Grease	13.49	1 Rectifier	3.2	0.24
Town 2.....	Grease	6.92	1 Rectifier	2.0	0.29
Town 3.....	Grease	8.32	1 Rectifier	4.0	0.48
Town 4.....	Grease	32.64	2 Rectifiers	15.1	0.46
Town 5.....	Grease	7.10	2 Rectifiers	8.8	1.24
Town 6.....	Enamel	3.65	1 Rectifier	0.4	0.11
Town 7.....	Enamel	4.78	Zinc	0.1	0.021
Town 8.....	Enamel	6.55	Zinc	0.74	0.113
Town 9.....	Enamel	8.87	Zinc	0.265	0.030



towns with grease coated piping have moderately high resistivity soils with small areas having low resistivity. Town 1 has highest resistivity soils and the lowest current consumption.

It may be of interest to note that Town No. 5 is the oldest completely protected grease coated system. It was completed and placed under protection in 1946. Current required for protection has not increased appreciably—and what has been added is due to system expansion.

#### Cathodic Protection Installation Cost Variations Explained

Installation costs for cathodic protection systems have varied widely. Earlier installations, particularly those made in 1941, were most expensive because personnel had to be trained, testing procedures developed, suitable equipment and materials found, and installation methods worked out. In order to compare costs of earlier installations with some more recent ones, the cost of several installations is compared.

##### A. 1.2 miles of 12-inch belt line protected in 1941— 4.7 miles of 3-inch equivalent

Materials and labor to insulate services and laterals.....	\$ 670.00
Material and labor for special tests.....	60.00
Material and labor for 2 rectifier installations.....	440.00
Engineering costs: Testing, design of system, special consultants and adjustment of protection.....	3910.00
Total .....	\$5080.00
Cost per mile of 3-inch equivalent.....	\$1080.00

##### B. Entire town distribution system protected in 1941— 3.22 miles of 3-inch equivalent

Materials and labor to insulate services.....	\$ 225.00
Material and labor for 1 rectifier installation.....	105.00
Engineering costs: Special and routine test, design of cathodic protection system, supervision of installation and final adjustment.....	680.00
Total .....	\$1010.00
Cost per mile of 3-inch equivalent.....	\$ 313.67

##### C. 6-inch high pressure distribution feeder protected in 1941—4.56 miles of 3-inch equivalent

Material and labor for insulating line.....	\$ 50.00
Materials for labor for 1 rectifier installation plus improvements and 1 galvanic anode installation.....	1700.00
Engineering costs: Special and routine tests, design of cathodic protection system, supervision of installation, and final adjustment.....	1600.00
Total .....	\$3350.00
Cost per mile of 3-inch equivalent.....	\$ 734.65

##### D. 5.78 miles 12-inch, 1.42 miles 10-inch, 6-inch and 2-inch protected in 1943—26 miles of 3-inch equivalent

Material and labor to insulate services and laterals and bond dresser couplings.....	\$ 4740.00
Material and labor for installing galvanic anodes.....	3920.00
Engineering costs: Special and routine test, design of cathodic protection and final adjustment.....	1500.00
Total .....	\$10,160.00
Cost per mile of 3-inch equivalent.....	\$ 391.00

##### E. Entire new town distribution system protected in 1947—11.61 miles of 3-inch equivalent

Material to insulate services.....	\$ 283.50
Material and labor for bonding couplings.....	38.00
Material and labor for 1 rectifier installation.....	342.00
Engineering costs: Design of cathodic protection system, supervision of installation, adjustment.....	720.00
Total .....	\$1383.50
Cost per mile of 3-inch equivalent.....	\$ 119.00

In items A and B, engineering costs were relatively high because much of it had to be charged off to training and development. In Item A, cost of insulating services was high as lines were insulated at the main rather than at the customers' meters because it was feared many contacts with foreign structures would be found on these services. This was the only installation insulated in this fashion, as it subsequently was found more practical to insulate at meters and clear such contacts as are found.

In connection with the 12-inch belt line in Item A, the next section to be protected after completing the 1.2-mile section itemized above was 1 mile in length (3.9 miles of 3-inch equivalent) and was placed under cathodic protection at a cost of \$1235.00 or \$316.00 per mile of 3-inch equivalent. The sharp drop in unit cost was due to the absence of training and development costs absorbed in the first section.

In Item E, it is to be noted that the cost of preparing a new town distribution system for cathodic protection is low if protection is provided for in the design of the system. Total cathodic protection installation cost for this town having grease coated piping was almost exactly 1 percent of the total cost of the distribution system. Cost of insulating services covers material alone because installation of insulated fittings costs no more than non-insulated fittings. Much of the engineering cost covers soil tests for locating suitable ground bed sites and clearing accidental contacts between the gas system and foreign structures.

When comparing the figures in item E with those in items A and B, it is to be remembered that costs of material and labor were appreciably higher in 1947 than in 1941. The cathodic protection cost for the 1947 installation is therefore cheaper in relation to the 1941 costs than the unweighted figures would indicate.

The gas company has applied protection to \$224,000 worth of new enamel coated mains and services during 1948 for less than \$1500.00 or 7/10 of 1 percent of the installed costs. When it is considered that the life expectancy of these mains and services has been extended a minimum of 20 years at a cost of less than 1 percent, it is hard to understand why all operators of underground structures are not applying 100 percent cathodic protection.

Average replacement cost per mile of 3-inch equivalent is estimated to be \$6000. The use of cathodic protection on the old mains as indicated in items A, C, and D resulted in an out-of-pocket saving of from \$4920 to \$5600 per mile of 3-inch equivalent. Cathodic protection was applied as a last resort before replacement in the above cases.

Maintenance costs on cathodically protected gas distribution systems are difficult to foretell because of many unforeseen requirements. Some major sources of maintenance expense experienced to date have involved installation of new uninsulated services on cathodically protected mains, occasional installation of new water services or other structures in contact with the protected gas system, repairing rectifier ground beds, vandalism, and changes made necessary

by civic improvements such as street widening and paving. Rectifier unit ground beds or galvanic anode installations will require replacement after they have been consumed. Present cost for an average size ground bed approximates \$250.00 to \$300.00 for material and labor. On systems protected by galvanic anodes, the anodes must be replaced after they are consumed. Normally this replacement will cost approximately 25 percent to 50 percent of the initial cathodic protection costs.

Installation of uninsulated new services on cathodically protected systems was a difficulty peculiar to the recent war period when insulating materials could not always be kept in stock. Normally this will not be a problem because with adequate insulating material stocks, it is now the policy to insulate all new services at the meter on all intermediate pressure mains—even if the mains are not cathodically protected. This practice tends to eliminate possibility of shorting out protective current on cathodically protected mains, reduces the amount of insulating work to be done if a section of a system now unprotected is to be protected at a later date, and, on unprotected mains, breaks up the corrosive couple between steel gas services and mains and cast iron or copper water system.

#### Coating Types Usually Minor Factor in Protection Costs

It has been mentioned that current requirements for cathodic protection depend largely on the types of pipe coating used. It might be well to estimate the difference between the yearly cost of protecting a grease coated distribution system with an estimated cost of the same system enamel coated.

A new distribution system completed by the combination company in 1948 has 32.64 miles of 3-inch equivalent in mains and services. This system initially was protected with two rectifier units having a combined output of 15.1 amperes or 0.111 milliamperes per square foot of pipe surface. Installation cost of the rectifiers and ground beds was \$935.00. Yearly cost of this investment including 6 percent return, 3 percent depreciation on rectifier equipment, and 6.7 percent depreciation on the ground beds is estimated to be \$103.95. Yearly cost of energy at cost for company use is about \$17.50 and total annual cost is \$121.45. This is \$3.72 per mile of 3-inch equivalent per year.

If this system had been coated with a good enamel coating, it is estimated all pipe in the town could have been protected with 1.35 amperes, total, from galvanic anode installations. With existing soil conditions, it is estimated it would have cost \$300.00 to install sufficient galvanic anodes for adequate protection and 15-year life. At 6 percent return and 6.7 percent depreciation, this would cost \$38.10 annually or \$1.17 per mile of 3-inch equivalent per year. Taking the town as a whole, it now costs \$83.35 per year more to cathodically protect it than it would have if it had been coated with enamel. This is not an attempt to indicate any preference in type of coating because there are many factors which determine coat-

ing, but is offered to show that for a system such as was described, the annual difference in cost is relatively small. For the town in question, if it were possible to apply the grease coating for an average of one cent per foot less than it would have cost to apply enamel (although we have no data which indicates that this would be possible), the money saving for the 38½ miles of pipe in the system would have been \$2033.00, which, at 6 percent return plus 3 percent depreciation is worth \$182.97 per year as compared to the \$83.35 per year added cost for cathodic protection as estimated above.

A gas distribution system completed by the gas company in 1948 has 4.88 miles of 3-inch equivalent in mains and services. Enamel coated pipe was used and the system protected with galvanic anodes. Total current requirement was 0.1 amperes or 0.0042 ma per square foot. Installation cost of galvanic anodes was \$280.00. Yearly cost of this investment, including 6 percent return, 2½ percent depreciation is estimated to be \$23.80.

Estimated cost of a rectifier installed at this location is \$300.00. Yearly cost of this investment is estimated to be \$25.50 plus a minimum power cost of \$12 per year. Because of exposed mounting of a rectifier and connecting wires it is expected that the maintenance cost of a rectifier would be greater than the galvanic anode installation, but assuming the maintenance cost the same, the total yearly cost would be \$13.70 more for the rectifier installation than the galvanic anodes.

From the above analysis it will be realized the method of applying cathodic protection is relatively unimportant when soils are such that a reasonable output may be obtained from galvanic anodes or power is available for rectifiers. Outstanding factor to be considered is the fact that the whole distributing system can be protected completely for the next 40 years using galvanic anodes for less than \$5.00 per mile per year. This is less than the installed cost of the smallest leak clamp.

#### Policy on Distribution System Construction

The present policy of these companies on application of cathodic protection is to use it as a standard adjunct to all new distribution systems built, to use it on all important new main construction in existing systems, and to use it for protecting older mains and services in areas where corrosion is a problem.

It is present practice to incorporate provisions for cathodic protection in construction specifications for new distribution systems. Principal provisions are that all services run shall be insulated at customers' meters, that all mechanical couplings shall be bonded across, that no gas main or service pipe shall contact any other underground structure, and that wherever gas pipe crosses another structure and comes within six inches of it, insulating blocks shall be placed between the structures to prevent their settling together. In addition, on larger systems, provisions are made to insert insulating-type couplings or to insulate valve flanges in such a manner that, electrically, the system may be separated into two or more sec-

tions. This simplifies maintenance by permitting isolation of a part of the system having trouble and results in quicker location of the source of difficulty.

Experience has shown the above described provisions in construction specifications, with adequate inspection, permit application of cathodic protection to the completed system with little or no additional work other than installation of the cathodic protection and adjustment of current output.

#### Engineering and Records Procedures

Unitl 1948, all cathodic protection installations were engineered by general office engineering personnel who also supervised installation and did the periodic test work required for maintenance. With the number of installations now in operation, it is becoming more practical to delegate responsibility for the major part of the engineering to various division offices within the company. This is being done this year but general office personnel still are available for assistance on special problems in addition to supervision of the overall cathodic protection program, investigation of new materials, equipment and procedures, and maintenance of standards.

Standards have been prepared covering all phases

of cathodic protection installation work to insure uniform installations and procedures throughout the companies.

Periodic tests are made on each installation to determine whether or not protective potentials are being maintained. Operation of all rectifier units is checked monthly by the combination company's meter readers who fill out a card showing voltage and current output of the rectifiers. Figures taken from these cards are posted on central records where they can be compared with previous entries and thereby detect changes which may be an indication of ground bed deterioration or changes in the cathodic protection requirements of the system.

The procedure is a particularly advantageous one for a combination company, in that it allows procurement of a periodic check on rectifiers performances at minimum cost.

The gas company, whenever practical, installs inexpensive indicating voltmeters between protected pipe and reference pipe such as unprotected gas or water mains at district regulation station or other frequently visited spot. The meters are read periodically by chart men who record this reading for reference.



## Discussions

Discussion on "EROSION-CORROSION OF METALS AND ALLOYS," by M. G. Fontana and W. A. Luce. CORROSION, 5, No. 6, 189-193 (1949) June.

Question by Harris Thompson, National Aluminate Co., Chicago, Ill.:

The oxygen content of the fluid used in any corrosion test is a very important part of the evaluation of results and in transference of the test results from the laboratory to field work. Thus it would be desirable to have the figures on oxygen content of the test solutions included in the reported results.

#### Authors Reply:

Oxygen contents of the solutions were not determined because these were merely "high-spot" tests. The solutions are "highly aerated" or "not artificially aerated." We are conducting tests under controlled aeration in another system which is completely enclosed. These results will be published later when the study has progressed far enough to warrant it.

Questions by H. H. Bennett, Socony-Vacuum Oil Co., Paulsboro, N. J.:

1. Is the erosion-corrosion rate of a metal in a corrosive dependent on its corrosion rate in that corrosive or is the erosion-corrosion rate independent of the corrosion rate?

2. Can the experimentally determined erosion-cor-

rosion rate of a metal in one corrosive be used to predict the erosion-corrosion rate in another corrosive, providing the corrosion rate of the metal is known in both corrosives? (It is assumed for the purpose of the question that the only condition that changes is the one that causes the erosive action).

#### Authors' Reply:

1. The erosion-corrosion rate is related to the corrosion rate (obtained in the absence of high velocity or wear effects) in many cases. In general, the higher the corrosion rate the higher the erosion-corrosion to be expected. However, there are many exceptions to this generalization so this rule should be used only in the absence of necessary information or experience. For example, Figure 5 in the paper indicates that the reverse may be true for the given conditions. In addition, our tests have shown that velocity of solution *decreases* the rate of pitting. (Pitting is aided and abetted by stagnant conditions). In some cases as shown in Figure 7 for lead, the erosion-corrosion rate is appreciable but no corrosion occurred in static or low velocity tests. The value of erosion-corrosion tests is to help eliminate the "guesswork" so often required when only static corrosion data are available.

2. The answer to this question is "no" and some of the above remarks apply. However, it would not be too wild a guess to say that the erosion-corrosion



rates would be of the same order of magnitude if the corrosion rates were essentially the same.

**Questions by James R. Harrison, The Pure Oil Co., Newark, Ohio:**

1. Did you use a copper salt as an inhibitor in one of your tests?

2. Have you done any work in which an inhibitor was used in an attempt to prevent corrosion or erosion-corrosion of lead?

**Authors' Reply:**

Copper sulphate was added to the slurry for the data shown in Figure 4 in the paper. Copper ions may be of some help in reducing erosion-corrosion of lead but we have not studied this item. The addition of lead ions to the solutions does decrease the erosion-corrosion of lead. In another series of tests it was shown that sulfuric acid added to water containing an organic wetting agent decreased the rate of erosion-corrosion tremendously. In this case, sulfuric acid could be considered as an inhibitor, if one wished to do so.

**Remarks by Lewis P. Aker, Louisville Gas & Elec. Co., Louisville, Kentucky:**

Extensive corrosion-erosion of carbon steel boiler feed pump casings and shafts has been experienced by the writer's firm. The feed water being pumped was at pH 8.0 to 8.4, and contained .02 to .05 ppm ammonia nitrogen and less than .5 ppm total solids. Temperatures were 200° to 270° F with most operation above 250°. The pumps were 3600 rpm, 5 or 6 stages, with split casings. Suction pressures were 25 to 60 psia and discharge pressures 1000 to 1150 psia.

The use of nickel-chromium alloys very similar to stainless for casings and shafts has apparently eliminated the trouble.

**Authors' Reply:**

Mr. Aker's description of his experience with boiler feed pumps is a valuable addition to the paper. His experience tends to corroborate our data which show destructive attack on steel in water with a pH 8.

**Question by H. O. Teeple, The International Nickel Co., Inc., New York:**

How are you able to distinguish the effect of corrosion-erosion from the galvanic effects of lead coupled with stainless steel in sulfuric acid application? It appears some of the weight loss of the speci-

men may be attributed to the galvanic effect rather than wholly to corrosion-erosion.

**Authors' Reply:**

The galvanic effect between lead and 18-8SMo in 10% sulfuric acid under static conditions is almost negligible. Figure 8 is shown to illustrate the destructive effect of erosion-corrosion on a galvanic couple.

**General:**

The authors wish to thank the discussors of this paper for their interest.

We would like to take this opportunity to rectify an omission from the acknowledgement during publication. Thanks are due to the Engineering Research Laboratory of E. I. du Pont de Nemours and Co. for permission to publish data one of the authors obtained in this company's laboratory some time ago.

**Discussion on "THE USE OF SELENIUM RECTIFIERS AS ONE-WAY VALVES IN ELECTROLYSIS DRAINAGE WIRES," CORROSION, 5, No. 10, 315-318 (1949) Oct.**

**Remarks by J. M. Standing, American Telephone & Telegraph Co., New York:**

Mr. Cannon's paper indicates that there may be a considerable field of use for dry-type rectifiers as reverse current valves. In the cases cited, it appears that the resistances in the drainage circuits were fairly high compared to the forward resistances of the rectifiers used, so that this latter resistance was not an important factor. In situations involving higher drainage currents and lower drainage circuit resistances, the resistance of the rectifier becomes important. Because the forward resistance of a rectifier increases rapidly with decreasing current, this effect is particularly pronounced at light loads. For instance, a rectifier that gives satisfactory drainage at moderate and heavy loads may fail to pass currents sufficient to provide adequate drainage at light loads. However, if this factor is recognized in the design and rectifiers of proper size are used, satisfactory performance appears possible during a good portion of a normal trolley load cycle. In general, the condition best suited to the use of a rectifier, within its voltage limitations, would seem to be one where the forward currents are large over the greater portion of the load cycle and approach low values for only a relatively short period before reversing.

# Electrolytic Corrosion of Steel in Concrete\*

By G. M. MAGEE

**I**N ELECTRIFIED railways the steel catenary structures are supported by concrete footings to which they are secured with anchor bolts. For safety reasons, the catenary structures are grounded to the return rail. At times when trains are in the immediate vicinity of the catenary structure, a potential of as much as 25 volts may exist between the structure and the ground. If direct current is used for power, a current flow from the structure through the anchor bolts and concrete into the ground results from this potential. The anchor bolts become corroded from this current flow and the resulting expansion due to the increased volume of the rust cracks the concrete, which permits water to contact the steel, further accelerating the deterioration.

The research staff of Association of American Railroads was asked to investigate this condition a few years ago. The first work was to excavate around several footings on the Cleveland Terminal where large current flow had been measured at various times. Inspection of these footings showed the presence of considerable water contacting the footings and some surface deterioration of the concrete was evident. After considerable discussion, it was decided that a field test would be established in which could be provided controlled conditions for study of the effect of various factors on the electrolytic corrosion of steel embedded in concrete.

A location on the Illinois Central right of way, just south of 23rd Street in Chicago, was selected because of its ready accessibility. A test house was constructed and equipped with a mercury arc rectifier to provide a 25-volt direct current potential. A small tract of land surrounding the building was fenced off to prevent trespassing. Within the enclosure three bus lines of bare copper wire were supported about 3 ft. above the ground, all three buses connecting into the 25-volt potential in the test building. The test specimens were buried in the ground on each side of the bus lines and the steel electrode connected to the bus. The test specimens consisted of a one-inch round steel rod six feet long, cast in concrete



G. M. MAGEE

Since 1937 research engineer with the engineering division, Association of American Railroads, Mr. Magee supervises research activities related to track and bridge structures. A graduate of University of Ill., BS, 1927, he has had 13 years' railway service with the KSC engineering department, and has conducted research for Carnegie-Illinois Steel Co. in 1933 and 1934 and American G.E.O. Co., including studies of track structure in Germany and England.

cylinders of various diameters and of a length to leave six inches of the steel electrode projecting from the top of the cylinder and a six-inch thickness of concrete covering the lower end of the electrode. The bus lines carried the positive side of the DC supply and the negative side was connected to steel rails embedded in the ground at the corners of the test area. The electrodes in the specimen were thus positive to the ground.

The first series of tests was started in April, 1944, and included specimens to determine the effect of various thicknesses of concrete covering, steel encasement, asphalt membrane waterproofing, cement proportioning, and use of various admixtures. The specimens were continuously charged with 25-volt potential for 15 months. At the end of this time it was evident that severe deterioration had taken place in many of the specimens especially those of the smaller diameter. For example, the specimens, with only two or three inches of concrete covering around

the electrode were almost completely disintegrated and as much as one-half of the electrode itself had corroded and disappeared. On the specimens of larger diameter, there was evidence of surface concrete deterioration and even on the specimens 25 inches in diameter with 12 inches of concrete protection around the electrode, the concrete was found to be split in three directions as a result of the corrosion expansion of the steel. None of the admixtures tried were of any benefit in arresting corrosion or deterioration of the concrete. One group of specimens was poured in a steel encasement and although there was no deterioration of the concrete in this specimen, the concrete itself had tiny cracks radiating out from the electrode. Of all of the specimens subjected to the DC current, only those having the asphalt membrane waterproofing were protected from deterioration and corrosion of the electrode. These particular specimens showed a very high resistance to ground with almost no current flow from the 25-volt potential. At the end of the 15 months, when the specimens were removed, for those encased with asphalt waterproofing the electrodes were found to be in as good condition as when originally installed with absolutely no indication of corrosion.

\*A paper presented at the Fifth Annual Conference of The National Association of Corrosion Engineers at Cincinnati, Ohio, April 11-14, 1949.

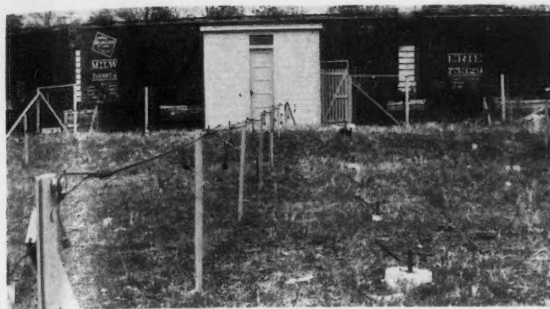


Figure 1—Field test set installation.

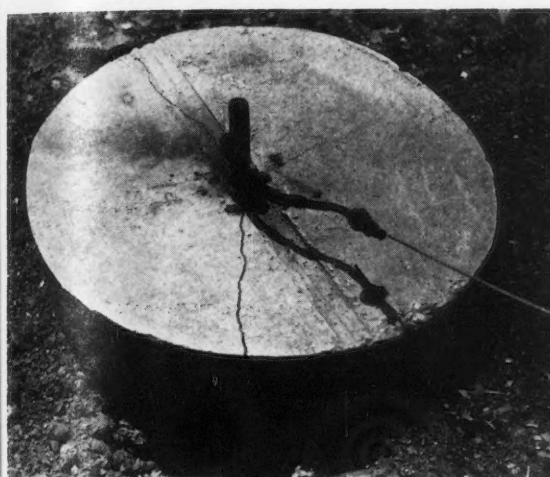


Figure 2—Specimen in place showing expansion cracks.

Another group of specimens were subjected during the same period to 110-volt alternating current. No deterioration of the concrete or corrosion of the electrodes were found with these specimens, which was to be expected because there has been no difficulty reported on electrified railways using alternating current for power.

The deterioration of the concrete that was found in these test specimens was entirely unexpected. It had been anticipated that the concrete would be cracked, but the extent of actual deterioration of the concrete itself in the smaller diameter specimens was entirely unlooked for. Dr. L. S. Brown, petrographer of the Portland Cement Association, was invited to examine these specimens, and he made a petrographic study of samples of the deteriorated concrete. As a result of his studies, he advanced the theory that the cause of deterioration was an aggravated sulfate attack at the surface of the concrete. He concluded that the entire concrete specimen acted as an electrode positive to the ground, attracting negative sulfate ions to the surface in great quantities. The resulting sulfate attack caused certain of the constituents in the cement to expand unduly, shattering the concrete so that it crumbled into fine particles.

Several questions were raised concerning results



Figure 3—Corroded specimens removed from ground.

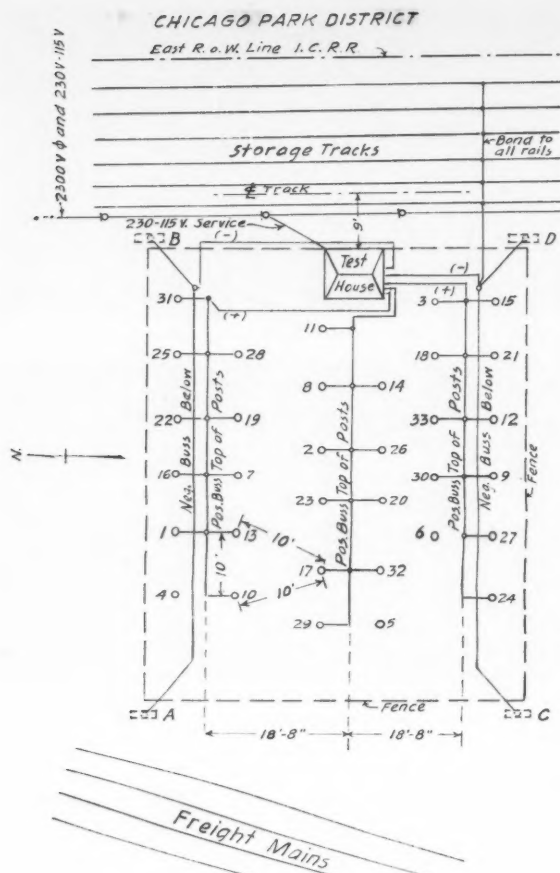
of this first series of tests, and it was decided that a second series should be run in order to clear them up. In this second series of tests, specimens were included of the following types:

- a) Sulfate resisting cement to verify the sulfate attack theory.
- b) Plain concrete specimens with and without current to establish a base for comparisons.
- c) Specimens with stainless steel electrodes.
- d) Completely steel-encased specimens—in the first series the concrete was exposed at the bottom end.
- e) Specimens with emulsified asphalt added to the concrete mix.
- f) Specimens in which the concrete was poured into forms which had been lined with asphalt membrane waterproofing. In practice it generally would be impractical to apply the waterproofing after the concrete was poured.
- g) Specimens having only the electrode coated with asphalt.
- h) Specimens with a wire mesh between the electrode and the surface to simulate the condition of anchor bolts surrounded by reinforcing steel.

This second series of specimens were placed in the ground and connected to the 25-volt potential on October 8, 1946, and the tests still are being continued. However, the current flow readings which have been taken and observations made around the specimens after partial excavation last fall have developed sufficient information to give quite conclusive results.

In this second test series as with the first series, only the specimens protected with the asphalt membrane waterproofing or those having the electrode coated with asphalt gave high resistance to ground, low current flow, and no evidence of electrode corrosion or concrete deterioration. The stainless steel electrodes were not corroded, nor was the concrete cracked, but there was evidence of surface deteriora-





Specimen Number	DESCRIPTION
1	Plain Concrete 1:3:5 Mix
2	Plain Concrete 1:3:5 Mix
3	Plain Concrete 1:3:5 Mix
4	Plain Concrete 1:3:5 Mix no Current
5	Plain Concrete 1:3:5 Mix no Current
6	Plain Concrete 1:3:5 Mix no Current
7	Plain Concrete 1:3:5 Mix Sulphate Resisting Cement
8	Plain Concrete 1:3:5 Mix Sulphate Resisting Cement
9	Plain Concrete 1:3:5 Mix Sulphate Resisting Cement
10	Concrete 1:3:5 Mix Reinf. Steel or Wire Mesh
11	Concrete 1:3:5 Mix Reinf. Steel or Wire Mesh
12	Concrete 1:3:5 Mix Reinf. Steel or Wire Mesh
13	Plain Concrete 1:3:5 Mix Stainless Steel Electrodes
14	Plain Concrete 1:3:5 Mix Stainless Steel Electrodes
15	Plain Concrete 1:3:5 Mix Stainless Steel Electrodes
16	Plain Concrete 1:3:5 Mix Stainless Steel Electrodes
17	Plain Concrete 1:3:5 Mix Stainless Steel Electrodes
18	Plain Concrete 1:3:5 Mix Stainless Steel Electrodes
19	Plain Concrete 1:3:5 Mix Stainless Steel Electrodes
20	Plain Concrete 1:3:5 Mix Stainless Steel Electrodes
21	Plain Concrete 1:3:5 Mix Stainless Steel Electrodes
22	Plain Concrete 1:3:5 Mix Electrode Coated with Asphalt
23	Plain Concrete 1:3:5 Mix Electrode Coated with Asphalt
24	Plain Concrete 1:3:5 Mix Electrode Coated with Asphalt
25	Concrete 1:3:5 Mix Encased in Steel Pipe, Welded Bottom
26	Concrete 1:3:5 Mix Encased in Steel Pipe, Welded Bottom
27	Concrete 1:3:5 Mix Encased in Steel Pipe, Welded Bottom
28	Concrete 1:3:5 Mix Containing Emulsified Asphalt
29	Concrete 1:3:5 Mix Containing Emulsified Asphalt
30	Concrete 1:3:5 Mix Containing Emulsified Asphalt
31	Plain Concrete 1:3:5 Mix Forms Lined with Asphalt Waterproofing
32	Plain Concrete 1:3:5 Mix Forms Lined with Asphalt Waterproofing
33	Plain Concrete 1:3:5 Mix Forms Lined with Asphalt Waterproofing

Figure 4—Installation for field test of electrolytic corrosion of steel in concrete. (Note: Negative electrodes, five feet of rail, buried horizontally in permanent moisture at locations A, B, C, D. Each treated with 50 pounds of salt.)

tion of the concrete presumably from sulfate attack. The specimens made of sulfate resisting cement showed considerably less surface deterioration of the concrete but the electrodes corroded and the concrete was cracked as a result thereof. The addition of emulsified asphalt to the concrete was of no advantage in preventing electrode corrosion, concrete cracking or deterioration. The specimens encased in the steel pipe showed low resistance and high current flow to ground and the electrode was corroded as evidenced by radial cracks extending from it in the concrete.

The conclusions reached from these two series of tests are as follows:

- Alternating current potential does not produce electrolytic corrosion of steel in concrete nor deterioration of the concrete.
- Direct current potential (with the steel and concrete anodic) will produce electrolytic corrosion of steel in plain concrete, cracking of the concrete, and deterioration of the concrete if it is in contact with soil containing sulfate ions, providing there is sufficient current flow.
- Electrolytic corrosion of steel in concrete, cracking of the concrete, and deterioration of the concrete underground may be prevented best by surrounding the concrete with asphalt membrane waterproofing to insulate it from the ground or by coating the steel with asphalt to insulate it from the concrete. The concrete may be poured into forms lined with the waterproofing or the waterproofing may be applied to the finished concrete. Should the steel only be coated then all steel tending to discharge current to the concrete must be coated. For example, in a foundation for a catenary structure, the anchor bolts and that portion of the catenary structure bearing directly on the concrete must be coated. Reinforcing steel used within the footing need not be coated.
- The passage of electric current through concrete does not in itself produce concrete deterioration.
- The use of richer mix or any of the admixtures included in the tests, including emulsified asphalt, were not effective.
- The use of stainless steel will greatly lessen the corrosion of the steel and cracking of the concrete but will not prevent concrete deterioration underground if sulfate ions are present in the soil.
- The use of sulfate resisting cement is helpful in preventing concrete deterioration underground, but will not prevent corrosion of the steel and resultant cracking of the concrete.

## DISCUSSION

Question by Sidney E. Trouard, New Orleans Public Service, Inc., New Orleans, La.:

What effect will be noted on the concrete if the steel were made cathodic?

We intend to apply cathodic protection to a mass of underground coated pipes and metal conduits in a large power generating plant. The pipes and conduits are all in intimate contact with the copper

station grounding system and also with many heavy reinforcing steel rods imbedded in concrete. It is of primary importance to us that the cathodic protection current which will collect on the steel reinforcing rods will not adversely affect the strength of the concrete.

We had heard that if steel in concrete maintained a potential to  $\text{Cu SO}_4$  of in excess of  $-1.0$  volt, there may be an evolution of hydrogen and the formation of alkali on the steel which would weaken the bond between the steel and the concrete and result in mushiness of the concrete near the steel.

#### Author's Reply:

In the tests on electrolytic corrosion of steel in concrete, described in my paper there were no specimens included where the steel was made cathodic. Accordingly we are not in position to offer any information on this subject from these particular tests.

Before we undertook the tests, however, we prepared a rather extensive bibliography, and reference to this shows that there is some history in earlier tests where a definite deterioration was found in the concrete surrounding the steel when the steel was

made the cathode or negative. These tests have been reported in *Engineering News*, Vol. 68, Pages 1162 and 1121, text 19 and 26, 1912, by Rosa MacCollum and Peters of the Bureau of Standards. The same authors published Bureau of Standard Technical Papers 1888 and 123 in 1913 which included additional information on this same subject.

#### Discussion by L. S. Brown, Senior Research Petrographer, Portland Cement Association, Chicago, Ill.

Mr. Magee has outlined two series of experiments in the electrolysis of concrete. Specific variables in the first series included richness of concrete mix, influence of admixtures, diameter of cylinders (3 inches to 25 inches), and direct vs. alternating current. Specific variables in the second series included metal of the electrode (anode), regular vs. special cements, waterproofing admixture, and non-energized control specimens. Both series included ordinary or plain exposure, and effect of protective coatings, conducting and non-conducting.

In all cases in which no current was passed, i.e., non-energized specimens and those with non-conducting coatings either on the electrode or around the cylinder, behavior was normal. The concrete appeared to be hard, sound, and unaffected in any

TABLE I—Current Readings  
Second Field Test—Electrolytic Corrosion of Steel in Concrete

25 Volts Direct Current Applied to Steel Electrode—Test Site on I.C.R.R. near 23rd St., Chicago, Ill. All Specimens Concrete 1-3-5 Mix, 13 in. Dia.

Specimen Number	DESCRIPTION	CURRENT FLOW IN AMPERES GIVEN DATE										Condition
		1946			1947				1948			
		Oct. 8	Oct. 21	Dec. 23	Jan. 10	Mar. 28	July 2	Oct. 3	Feb. 18	June 3		
		Weather	Dry	Moist	Moist	Snow Frozen	Frozen	Moist		Wet	Dry	
1	Plain Concrete.....	.393	.315	.210	.145	.240	.247	.340	.380	.156	D	
2	Plain Concrete.....	.410	.355	.232	.210	.158	.165	.198	.240	.380*	D	
3	Plain Concrete.....	.344	.291	.220	.196	.154	.174	.116	.118	.092	C	
4	Plain Concrete.....	No Voltage Applied										B
5	Plain Concrete.....											A
6	Plain Concrete.....											A
7	Resisting Cement.....	.564	.417	.228	.200	.180	.228	.340	.240	.280	C	
8	Resisting Cement.....	.340	.198	.190	.116	.124	.142	.172	.106	.136	A	
9	Resisting Cement.....	.363	.248	.156	.123	.126	.170	.156	.170	.190	A	
10	Wire Mesh.....	.602	.405	.400	.560	.480	.542*	.580	.270	.280	C	
11	Wire Mesh.....	.351	.240	.288	.172	.220	.200	.260	.180	.220	C	
12	Wire Mesh.....	.405	.312	.228	.180	.188	.232	.270	.300	.220	C	
13	Stainless Electrodes.....	.433	.332	.210	.180	.230	.242	.300	.340	.180	B	
14	Stainless Electrodes.....	.313	.188	.180	.126	.156	.170	.168	.152	.160	B	
15	Stainless Electrodes.....	.210	.110	.099	.078	.092	.170	.098	.080	.104	A	
16	Stainless Electrodes.....	.478	.350	.220	.194	.240	.278	.420	.194	.220	B	
17	Stainless Electrodes.....	.392	.270	.220	.210	.220	.283	.320	.280	.260	B	
18	Stainless Electrodes.....	.325	.240	.192	.176	.166	.210	.176	.138	.220	A	
19	Stainless Electrodes.....	.402	.312	.220	.220	.210	.240	.220	.154	.240	B	
20	Stainless Electrodes.....	.494	.402	.248	.220	.240	.258	.420	.300	.220	B	
21	Stainless Electrodes.....	.325	.253	.220	.137	.182	.205	.140	.130	.146	A	
22	Elect. Asphalt Coated.....	.015	.003	.003	.002	.001	.001	.004	.003	.005	A	
23	Elect. Asphalt Coated.....	.054	.012	.022	.008	.005	.009	.015	.008	.016	A	
24	Elect. Asphalt Coated.....	.072	.013	.034	.012	.008	.013	.031	.036	.090	A	
25	Encased in Steel.....	.453	.512	.120	.230	.140	.192	.210	.044	.114	B	
26	Encased in Steel.....	1.240	.810	2.80	3.80	5.80	4.80	.340	.099	.220	B	
27	Encased in Steel.....	.958	.893	.500	.280	.188	.324	.260	.074	.220	B	
28	Emulsified Asphalt.....	.262	.185	.173	.120	.150	.154	.116	.033	.092	D	
29	Emulsified Asphalt.....	.570	.340	.410	.230	.300	.784*	.420	.340	.260	D	
30	Emulsified Asphalt.....	.502	.372	.232	.162	.163	.238	.350	.300	.280	D	
31	Asphalt Waterproofed.....	.040	.005	.009	.003	.005	.008	.009	.010	.014	A	
32	Asphalt Waterproofed.....	.028	.012	.015	.009	.007	.008	.014	.013	.019	A	
33	Asphalt Waterproofed.....	.110	.022	.020	.011	.009	.015	.028	.016	.028	A	

A—Excellent condition. No cracks or deterioration of concrete.

B—No cracks. Concrete slightly discolored and deteriorated.

C—Small cracks. Concrete somewhat discolored and deteriorated.

D—Large cracks and concrete badly discolored and deteriorated.

\*—Fuse found open, replaced and voltage applied.

Note—The surface of the concrete of the steel encased and asphalt coated specimens could not be examined without destroying them. This examination will be made later.

way. The same normal behavior was exhibited by those specimens subjected to alternating current. In all other cases the integrity of the concrete was variously impaired.

Damage sustained appeared to be of two types. One type was an axial splitting of the cylinders, radially about the central electrode. The splitting obviously was related to expansion of the electrode. The other type was a softening, discoloration, and minute disintegration of the concrete, evidently proceeding from the outer surface inwardly. In the 15 months exposure of the first series this had progressed variably with cylinder diameter. The 6-inch or less diameter cylinders were fully disintegrated, but disintegration of the 25-inch cylinder was limited to about  $\frac{1}{2}$ -inch. Inner concrete of larger cylinders apparently was unaffected. Both types of damage appeared in cylinders with ordinary exposure and ordinary steel electrodes. Surface disintegration alone appeared in uncoated cylinders with stainless steel electrodes. Radial cracking alone appeared in cylinders with conducting protective coatings, i.e., concrete cast and encased in steel pipe.

The purpose of petrographic examination of these specimens was to discover the nature of the damaging processes. With respect to the radial cracking, the concrete exhibited no evidence of damage other than mechanical disruption. Micro-structure and hydrous compounds differed in no discoverable feature from those present in normal concrete. Mechanical disruption was caused by enlargement of the central electrode, and the latter, in turn, was found to represent a progressive alteration of the steel to a hydrous iron oxide with greater mass and much lower specific gravity. The altered material appeared as a compact, almost black solid between electrode and concrete. The material was crystalline and was identifiable as goethite or lepidocrocite, each having the chemical formula  $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$ . Evidently the positively charged electrode was drawing to it negatively charged oxygen and OH ions. The most perfect expression of this development was in the cylinders encased with steel pipe. In these the oxide film was a shell, uniformly about  $\frac{1}{8}$ -inch thick, and radially fibrous in structure.

With respect to surface disintegration of the concrete, one manifestation was a powdery gray film forming on the outer surface of the affected cylinders. Occasional heavier concentrations served to cement pieces of cinder to the surface. This material was found to be finely crystalline gypsum. Intimately distributed throughout the disintegrating material there was a relative abundance of a densely matted, finely fibrous secondary material. In an earlier report on the first series this was identified as the "low" form of calcium sulpho-aluminate,  $\text{C}_3\text{A} : \text{CaSO}_4 : 12\text{H}_2\text{O}$ . Subsequent work has revealed this identification to be in error, and that the mineral is finely fibrous gypsum. In a number of respects, optical properties of the two are closely similar.

Sulphate disintegration thus was indicated and it was for this reason that a sulphate resistant cement was included in the second series. Such a cement as explicitly defined was not available at the time, but

a low  $\text{C}_3\text{A}$  cement close to the desired composition was used. In usual occurrences of sulphate attack the disintegration is effected by secondary formation of the "high" form of calcium sulpho-aluminate,  $\text{C}_3\text{A} : 3\text{CaSO}_4 : 32\text{H}_2\text{O}$ , which should be abundant in a concrete so badly distressed as in this case. Actually some of the "high" form was observed, though distinctly minor in occurrence.

These observations indicated also that the  $\text{SO}_2$  required for formation of these minerals was coming in from the outside, specifically from the cinders comprising a significant portion of the made ground. Chemical tests therefore were made on samples of outer disintegrating material and inner unaffected material from each of the two cylinders. Within the inner portions, normal  $\text{SO}_3$  contents of 1.7 and 1.6 per cent, on the cement basis, were found. In the disintegrating portions,  $\text{SO}_3$  contents were 8.9 and 13.9 per cent, these values being from 5 to nearly 10 times as much as could be accounted for by the cement.

Evidently, under the action of direct current the positive electrode strongly attracts  $\text{SO}_4$  ions from the outside. On entering the concrete these may react not only with the lime aluminates to form calcium sulpho-aluminate but also with calcium hydroxide, prominently present in all hydrating cements, to form gypsum. The latter reaction also is disintegrative. The indication therefore is that a sulphate resistant cement will not necessarily obviate deterioration, although results in the second series, as Mr. Magee has pointed out, indicated that rate of attack was slower than with the regular cement.

In summary, there was no indication in these test specimens that passage of electric current through the concrete had of itself effected any alteration in either the normal mineral composition or microstructure of the hydrated cement. These findings are in agreement with results of other experiments on the electrolysis of concrete reported in the literature. Damage here observed was confined to mechanical disruption by expansive hydroxidation of the electrode and sulphate disintegration from the outside. Evidently, in non-sulphate surroundings the latter would not occur.

On the other hand, the rate of disintegration of the concrete in these experiments must have been vastly greater under continuously applied current than may be expected in catenary support bases in field service. The writer has been present on two occasions to witness excavation around old tower footings in the Chicago Yards. The concrete in each case was found to be sound and in good condition, except possibly some top surface disintegration from freezing and thawing. There was no evidence of sulphate attack nor of cracking about anchor bolts. The latter, exposed by breaking open the embedding concrete by hammer, were found to be clean and sound, with no significant indication of rust. Presumably, the manner of deterioration of the tower bases described by Mr. Magee for the Cleveland Terminal is illustrated by the results shown in these experiments, although the writer has not had an opportunity to examine specimens from those structures.

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# Corrosion in Petroleum Processes Employing Aluminum Chloride\*

By R. S. TRESEDER\* and A. WACHTER\*

## Abstract

Many of the commercial processes for isomerization of paraffinic hydrocarbons, e.g., butane, use either of two types of anhydrous liquid catalysts containing aluminum chloride with hydrogen chloride present as catalyst promoter. The type which consists of an aluminum chloride-hydrocarbon complex has been found to be similar to aqueous hydrochloric acid in its corrosiveness to many alloys. For this catalyst complex satisfactory inhibition of corrosion in one process has been obtained by addition of ca. 0.4 percent antimony trichloride. Factors controlling corrosion by this catalyst complex are discussed and mechanism for the corrosive action of this catalyst and for its inhibition are presented.

The other liquid catalyst commonly used, a liquid melt of aluminum chloride and antimony trichloride, while appreciably less corrosive than the hydrocarbon complex type, is sufficiently corrosive to carbon steel under some plant conditions to require use of resistant alloys such as nickel. Plant corrosion experience with processes employing this catalyst is discussed. Data relating to factors influencing the corrosiveness of this catalyst are presented, and a mechanism for the corrosion reaction is proposed.

## Introduction

CONSIDERABLE use in petroleum processing has been made of the catalytic activity of aluminum chloride for promotion of cracking, alkylation and isomerization reactions. Of particular interest in recent years are the applications of aluminum chloride as an isomerization catalyst. Catalytic isomerization of *n*-butane provides a large portion of the isobutane feed required for the production of alkylate for aviation gasoline. Isomerization of higher paraffins and naphthenes to give products with more desirable properties (e.g. increased octane number) is also accomplished through use of aluminum chloride.

Corrosion has presented serious design and operating problems in many of these isomerization processes, particularly those which employ a liquid catalyst mixture. In many cases the production record of an isomerization plant has been determined largely by the degree of success attained in solving these corrosion problems. In processes employing the aluminum chloride-hydrocarbon complex type of liquid catalyst, choice of corrosion resistant materials for many equipment items is limited to special alloys and to a few nonmetallic materials. Applicability of nonmetallic materials is further limited by the pressures involved, e.g. ca. 400 psig. in the case of butane isomerization. However, inhibitors have been developed

which have allowed use of common alloys in some processes employing the complex type of catalyst. From a scientific standpoint, corrosion by these liquid catalyst mixtures has very interesting aspects since it involve nonaqueous systems having polar characteristics.

The various commercial isomerization processes that have been developed involve the following general steps: 1) hydrocarbon feed, to which anhydrous hydrogen chloride has been added to serve as catalyst promoter, is passed into one or more reaction vessels wherein intimate contact with the catalyst is accomplished, 2) hydrocarbon is separated from residual catalyst, and 3) hydrogen chloride removed from the isomerized product, usually by fractionation followed by a soda wash.<sup>1</sup> The principal process variations involve 1) whether the hydrocarbon feed is handled as a gas or as a liquid, 2) type of support or solvent employed for the catalyst, 3) manner of catalyst regeneration, if any. Corrosion becomes a serious design and operating factor only in that part of the process where aluminum chloride is present and particularly in those processes which employ a liquid catalyst. Hydrogen chloride removal from hydrocarbons via fractionation can be done safely in steel equipment providing completely anhydrous conditions are maintained. In all cases the reaction systems are under anhydrous conditions and operate at temperature of the order of 80 to 100° C. (176 to 212° F.).

In this article corrosion data are presented relating to two types of liquid catalysts that have been used in commercial isomerization processes: 1) aluminum chloride-hydrocarbon-hydrogen chloride complex, a typical composition being 58 percent  $AlCl_3$ , 4 percent  $HCl$ , and 38 percent hydrocarbon, and 2) aluminum chloride-antimony trichloride melt with a typical composition of 10 percent  $AlCl_3$ , 90 percent  $SbCl_3$ .

## I—Corrosion by Aluminum Chloride-Hydrocarbon Complex

Anhydrous aluminum chloride reacts with many hydrocarbon materials to form fluid complexes. Those employed in isomerization processes are dark colored liquids of moderate viscosity, immiscible with liquid hydrocarbons and possessing polar characteristics. They react readily with many materials, and, in general, are quite corrosive to metals, especially under the conditions employed in isomerization processes. The total aluminum chloride concentration of such complexes may be approximately 60%w, and in addition hydrogen chloride may be present in the complex at a concentration of ca. 4%w. It is con-

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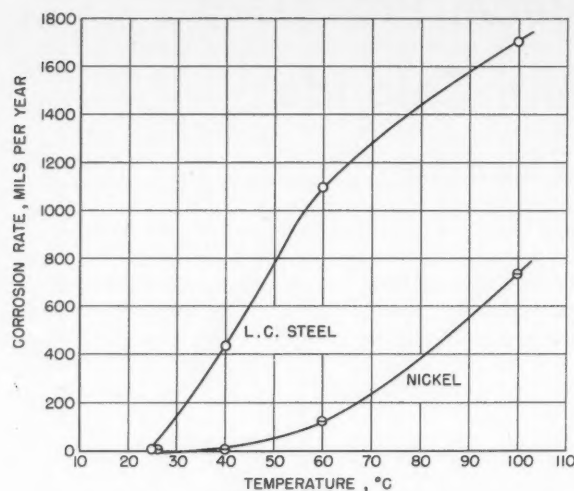


Figure 1—Effect of temperature on the Corrosiveness of aluminum chloride complex catalyst. Conditions: Aluminum chloride—aromatic hydrocarbon—hydrogen chloride complex. System blanketed with HCl gas at atmospheric pressure. Mild agitation. Duration of test 24 hours. 8 ml. corrosive/sq. in metal surface.

sidered by some that catalytic activity of these mixtures is due to the presence of an intermediate acidic compound,  $\text{HAlCl}_4$ .<sup>2</sup> Reactivity of the complex varies with the nature of the hydrocarbon molecule associated with the aluminum chloride, olefins in general giving less reactive complexes than aromatic hydrocarbons. Character of the complex changes with time owing to polymerization, cyclization, or alkylation of the hydrocarbon components. During actual use other secondary reactions take place which serve to alter further the nature of the complex; these reactions involve the feed material itself as well as feed impurities such as oxygen and water. The general effect of these changes in the catalyst is to give a liquid of increased viscosity, decreased catalytic activity, and, as will be shown later, decreased corrosiveness. The variable nature of these complexes is an important factor in the study of their corrosion behavior.

TABLE I. Corrosion of Various Alloys by Aluminum Chloride Complex Catalyst

Conditions: 200 ml. aluminum chloride-aromatic hydrocarbon-hydrogen chloride complex. Specimens (5 sq. in. each) all in same glass vessel. System blanketed with HCl gas at atmospheric pressure. Mild agitation. Duration, 1 day. Corrosion rates calculated from weight loss.

Alloy	Corrosion Rate, Mils./Yr.
Carbon Steel.....	2100
5% Ni Steel.....	2200
Type 316 Stainless Steel.....	1500
Nickel.....	150
Hastelloy B.....	2

TABLE II. Corrosion by Aluminum Chloride Complex Catalyst Under Reaction Conditions

Conditions: 100 ml. aluminum chloride-aromatic hydrocarbon-hydrogen chloride complex in glass reaction vessel. Dry  $\text{C}_7$  hydrocarbon feed containing 0.1%w HCl passing through vessel at rate of 1200 ml. per hour. 80° C. One or two specimens (2.8 sq. in. each) as stirrers rotating at 900 rpm. Air excluded. Corrosion rates calculated from weight loss.

Exp. No.	Alloy	Duration, Hr.	Corrosion Rate, Mils./Yr.
1	Carbon Steel.....	43	640, 640
2	Nickel.....	31	90, 90
3	Hastelloy B.....	62	0.3

The data reported here were obtained largely under conditions relating to one particular process, that of isomerizing a  $\text{C}_7$  mixed paraffin and naphthene fraction using aluminum chloride-hydrocarbon complex catalyst. In a recent paper, Fragen, Nysewander, and Hertwig<sup>3</sup> present extensive plant corrosion data obtained under conditions employed in isomerization of butane, pentane, and hexane with this type of catalyst. Their findings on relative corrosion resistance of various alloys are in substantial agreement with the experience described here.

### Corrosion Resistance of Alloys

In the reactor of a  $\text{C}_7$  isomerization plant operating with complex type catalyst at approximately 100° C. without catalyst regeneration, catalyst being replaced with fresh catalyst at definite intervals, it was found that the following alloys suffered severe corrosion: carbon steel, silicon bronze, Monel, nickel, Type 304 stainless steel, and Durimet T (see Table XVII for compositions of alloys used in these and following tests). These data were obtained by observations of either test specimens or auxiliary equipment items. A nickel-clad steel vessel showed severe corrosion after only a few weeks operation, the cladding (0.1 inch) being almost penetrated in some locations. Hastelloy B was the only alloy tested which was found to be substantially resistant to attack. Severity of the corrosive attack on various alloys is indicated by the laboratory data summarized in Table I which were obtained with freshly prepared catalyst in the absence of a hydrocarbon phase. Similar data were obtained under actual isomerization conditions (Table II). It is interesting to note that the relative degree of corrosion observed with the various alloys tested corresponds quite well with what would be expected in aqueous hydrochloric service.

### Factors Influencing Catalyst Corrosiveness

**Temperature.** Temperature has a marked influence on corrosiveness of the complex as indicated by the data shown graphically in Figure 1. Carbon steel was corroded very slightly at 25° C., but the corrosion rate increased rapidly with increasing temperature. The effect with nickel was similar except that the rapid increase started at a slightly higher temperature. The apparent slowing of the rate of increase of corrosiveness indicated for temperatures above 60° C. was probably due to effect of dissolved iron (see below).

**Effect of Dissolved Iron.** Successive corrosion tests carried out with the same sample of catalyst over a period of five days showed a marked decline in corrosiveness to both carbon steel and nickel after the second day (Table III) despite the fact that an excess of hydrogen chloride was present throughout the entire period. This effect was shown to be associated with the increased iron content of the catalyst (see also Table VIII). This is particularly significant in evaluating laboratory and pilot plant test results because in the latter tests the ratio of metal surface to catalyst volume is usually much higher than would be the case in a full scale plant; hence long term

laboratory or pilot plant tests would give misleading low corrosion rates.

**Catalyst Composition.\*** It was found that catalyst mixtures prepared from some technical grades of aluminum chloride were appreciably less corrosive than those from grades of higher purity. Analysis revealed that this effect could be traced to the presence of iron and other impurities, e.g. arsenic (see section on inhibition). Activity of catalyst prepared from such impure aluminum chloride was relatively low.

Addition of a small amount of water to the complex type catalyst was without appreciable effect on its corrosiveness. Large amounts of water would of course destroy the complex by converting the aluminum chloride to the oxychloride.

As the catalyst was used in the isomerization process its catalytic activity declined, it became more viscous, and, as shown in Table IV, its corrosiveness decreased markedly. This was attributed to reaction of the aluminum chloride with feed impurities, e.g., water, and with the feed itself.

**Galvanic Effects.** Aluminum chloride-hydrocarbon complex catalysts are polar liquids of appreciable conductivity and, as would be expected, galvanic corrosion effects can occur. For example, laboratory tests showed coupling of carbon steel to nickel resulted in significant protection of the nickel.

**Corrosion Mechanism.** It is believed the principal corrosion reaction involves hydrogen chloride as the corrosive, the reaction proceeding as follows:



Hydrogen has been identified as one of the products of the corrosion reaction. Direct reaction of iron with aluminum chloride would not be expected.

**Inhibition.** Effective solution of the serious corrosion problem presented by use of aluminum chloride-hydrocarbon complex in the  $C_7$  isomerization process was provided by use of antimony trichloride as inhibitor. The previously mentioned severe corrosion of nickel-clad reactor vessels was stopped by initial addition of a small amount of antimony trichloride to the catalyst, its concentration being maintained by continuous addition of inhibitor to the hydrocarbon feed. Several weeks of operation without inhibition had led to partial failure of the nickel-lining. Repair of the most severely corroded areas and inauguration of antimony trichloride inhibition resulted in corrosion being stopped so effectively that subsequent inspection a year later showed no significant additional attack had occurred.

Choice of antimony trichloride was based on laboratory work described below. In the course of this

\* Various aromatic hydrocarbons, e.g., toluene, were employed in preparing the complex type catalyst. Nature of the aromatic hydrocarbon was without apparent effect on corrosiveness of the catalyst.

TABLE III. Influence of Time on Corrosiveness of Aluminum Chloride Complex Catalyst

Conditions: Aluminum chloride-aromatic hydrocarbon-hydrogen chloride complex. All specimens in same glass vessel (13 ml. corrosive/sq. in. steel surface). Fresh specimens (5 sq. in. each) successively immersed in same batch of catalyst, 80° C. System blanketed with HCl gas at atmospheric pressure. Mild agitation. Corrosion rates calculated from weight loss.

Period, Hours	Corrosion Rate, Mils./Yr.		Calculated Iron Content of Catalyst at End of Period
	Carbon Steel	Nickel	
0-24	2400	170	5.2%w
24-48	590	59	6.5
48-111	3	0.4	6.5

TABLE IV. Corrosiveness of Spent Aluminum Chloride Complex Catalyst

Conditions: Aluminum chloride-aromatic hydrocarbon-hydrogen chloride complex plus 300 ml.  $C_7$  hydrocarbon in glass reaction vessel, 80° C. HCl atmosphere. Two specimens of carbon steel (2.8 sq. in. each) as stirrers rotating at 900 rpm. Duration, 24 hr. Corrosion rates calculated from weight loss.

Catalyst	Catalyst Volume	Corrosion Rate, Mils./Yr.
Fresh	100 ml.	2000, 2100
Spent (From runs such as described in Table I but with no Fe present.)	20 ml.	50, 60

TABLE V. Arsenic Compounds as Inhibitors of Corrosion by Aluminum Chloride Complex Catalyst

Conditions: Aluminum chloride-aromatic hydrocarbon-hydrogen chloride complex, 80° C. System blanketed with HCl at atmospheric pressure. Mild agitation. Corrosion rates calculated from weight loss. 13-20 ml. corrosive/sq. in. metal surface.

Exp. No.	Inhibitor	Conc., %w As	Period, Hour	Corrosion Rate, Mils./Yr.	
				Carbon Steel	Nickel
1	None	.....	0-24	5600.	170.
2	As <sub>2</sub> O <sub>3</sub>	0.04	0-24	1170.*	37.
3	As <sub>2</sub> O <sub>3</sub>	0.08	0-24 24-87	11. 4.*	.....
4	As <sub>2</sub> O <sub>3</sub>	0.23	0-24 24-72	4. 2.	.....
5	As <sub>2</sub> O <sub>3</sub>	0.23	0-137	0.6*	8.
6	AsCl <sub>3</sub>	0.41	0-24 24-136	1. 3.	.....

Conditions: 100 ml. aluminum chloride-aromatic hydrocarbon-hydrogen chloride complex plus 300 ml.  $C_7$  hydrocarbon in glass reaction vessel, 80° C. HCl atmosphere. Two specimens of carbon steel (2.8 sq. in. each) as stirrers rotating at 900 rpm. 24 hours.

Exp. No.	Inhibitor	Conc., %w As	Corrosion Rate, Mils./Yr.
1.....	None	.....	2000, 2100.
2.....	As <sub>2</sub> O <sub>3</sub>	0.23	13., 13.

\* Pitting occurred.

TABLE VI. Antimony Chloride as Inhibitor of Corrosion by Aluminum Chloride Complex Catalyst

Conditions: Aluminum chloride-aromatic hydrocarbon-hydrogen chloride complex with SbCl<sub>3</sub> added as inhibitor. 80° C. System blanketed with HCl at atmospheric pressure. Mild agitation. 10 ml. corrosive/sq. in. metal surface.

Exp. No.	Conc., %w Sb	Period, Hour	Corrosion Rate, Mils./Yr.	
			Carbon Steel	Nickel
1.....	.....	0-20	3500	110
2.....	0.11	0-24 24-89	7 6*	2 12*
3.....	0.21	0-21 21-88	6 9	1 1

\* Pitting occurred.



work other inhibitors were developed, but none offered the practical advantages of antimony trichloride.<sup>4</sup>

In a laboratory search of possible inhibitors the most promising results were obtained with arsenic and antimony compounds. Data for these inhibitors are given in Tables V and VI. Substantially complete inhibition of the corrosion of both carbon steel and nickel was obtained with 0.2 percent arsenic added either as arsenious oxide or as arsenic trichloride. Insufficient inhibitor concentration resulted in pitting, an effect similar to that observed with this inhibitor in aqueous acid systems. Presence of a hydrocarbon phase was without effect on inhibition. It was observed that continual light abrasion, such as given by a glass rod touching a moving specimen, would lead to local attack at the abraded area, owing to removal of the protective arsenic coating. However, moderately high liquid velocities (*ca.* 10 ft./sec.) were without apparent effect on the protective coating. Inhibition would be presumed to follow the same mechanism as in aqueous systems, i.e., deposition of

an adherent film of metallic arsenic on the cathode areas which, owing to the high hydrogen overvoltage of arsenic, stifles the normal cathode reaction involving discharge of hydrogen ions.

Antimony compounds, e.g. antimony trichloride, showed pronounced inhibition properties, being effective at a concentration of 0.2 percent Sb. There were indications that inhibition was possible at temperatures as high as 120° C.

One limitation upon use of these two inhibitors is their appreciable solubility in the liquid hydrocarbon being treated. Distribution ratio at 80° C. of arsenic trichloride between C<sub>7</sub> hydrocarbon and fresh catalyst was found to be about 3; of antimony trichloride, 0.2. The relatively low ratio for antimony trichloride would be a strong factor in its favor. To offset this extraction would require either 1) continuous injection of the inhibitor and subsequent wastage, probably via the soda wash, of the inhibitor extracted by the hydrocarbon, or 2) recirculation of an inhibitor-rich hydrocarbon stream supplied by suitable distillation.

Some data (Table VII) are available to show that inhibition with antimony is possible in catalyst complexes formed from paraffinic hydrocarbons.

As noted above, corrosiveness of the catalyst mixture declines to very low values after sufficient corrosion of carbon steel has occurred to give approximately 6 percent iron in the catalyst. It was found (Table VIII) that the same effect was achieved following rapid solution of an equivalent quantity of finely divided iron in the catalyst. The catalyst increased in viscosity, and process studies showed this material to be somewhat less active catalytically than iron-free catalyst. Addition of sodium chloride and calcium chloride in concentrations of the order of 10 percent also reduced the corrosiveness of the complex. A probable explanation for this effect is that the added salt serves to decrease the acidity of the catalyst through formation of compounds such as Fe(AlCl<sub>4</sub>)<sub>2</sub> and Na AlCl<sub>4</sub> instead of the corrosive H AlCl<sub>4</sub>.

## II. Corrosion by Aluminum Chloride-Antimony Trichloride Catalyst

An anhydrous molten salt mixture of aluminum chloride and antimony trichloride has been used effectively in processes developed for liquid phase isomerization of n-butane and other normal paraffins, and a number of full scale plants are in operation. A description of these processes is given in a recent paper by McAllister et al.<sup>5</sup>

Aluminum chloride dissolves in molten antimony trichloride to give a simple solution with an eutectic melting at 67° C and containing 7.5%w aluminum chloride. For isomerizing butane 8 to 12 percent aluminum chloride is employed in the catalyst mixture and appreciable anhydrous hydrogen chloride is added to the feed in order to activate the aluminum chloride. Total pressure on the reaction system is approximately 300 psig. and the temperature is 80-90° C. For pentane isomerization similar conditions are employed with the exception of lower aluminum chloride concentration (*ca.* 3%) and hydrogen

TABLE VII. Antimony as Inhibitor for Corrosion of Carbon Steel by Aluminum Chloride-Paraffinic Hydrocarbon Complexes

Conditions: Aluminum chloride-hydrocarbon-hydrogen chloride complex. Mild agitation. 90° C. 1 day. System blanketed with HCl at atmospheric pressure. Carbon steel specimen (10 ml. corrosive/sq. in.)

Exp. No.	Hydrocarbon Used in Preparing Complex	SbCl <sub>3</sub> Added, %w Sb	Corrosion Rate, Mils./Yr.
1	n-heptane	None	600.
2	n-heptane	1.1	6.
3	mixed octanes	None	400.
4	mixed octanes	1.1	7.

TABLE VIII. Influence of Various Salts on Corrosion by Aluminum Chloride Complex Catalyst

Conditions: Aluminum chloride-aromatic hydrocarbon-hydrogen chloride complex with added inhibitor. 95-100; C. System blanketed with HCl at atmospheric pressure. Mild agitation. 24 hr. 8 ml. corrosive/sq. in. metal surface.

Exp. No.	Inhibitor	Conc., %w	Corrosion Rate, Mils./Yr.	
			Carbon Steel	Nickel
1	None	....	910.	170.
2	Fe*	6.†	50.	18.
3	NaCl	5.7	260.	180.
4	NaCl	10.7	80.	16.
5	CaCl <sub>2</sub>	ca. 10.	9.	....

\* Added as steel wool; complete solution obtained before start of test.  
† Equivalent to 13.6% FeCl<sub>2</sub>.

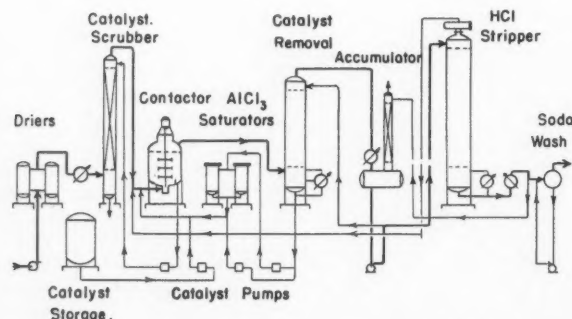


Figure 2—Flow diagram for butane isomerization using aluminum chloride-antimony trichloride catalyst.

being added to the feed stream to suppress disproportionation.

A typical flow diagram for the butane isomerization process is given in Figure 2. The process briefly is as follows: Liquid n-butane feed is dried, then preheated to ca. 70° C. before passing to the catalyst scrubbing column, where it flows counter current to a side-stream of catalyst from the contactor, thus serving to extract  $\text{SbCl}_3$  and active  $\text{AlCl}_3$  from the catalyst mixture, leaving as a residue to be rejected relatively inactive hydrocarbon- $\text{AlCl}_3$  complex. The feed then flows to the bottom of the contactor where it is met by a recycle hydrogen chloride stream and a make-up catalyst stream. Inside the contactor the catalyst mixture and feed are strongly agitated, the isomerized liquid hydrocarbon being taken off from a settling zone at the top of the contactor and passed to a catalyst removal column. In this column the bottoms product is  $\text{SbCl}_3$ , containing some  $\text{AlCl}_3$ , which is returned to the contactor, a portion of the  $\text{SbCl}_3$  stream goes through the  $\text{AlCl}_3$  saturators wherein fresh  $\text{AlCl}_3$  is dissolved in the melt. The hydrocarbon product is taken overhead from the catalyst removal column and in the next column hydrogen chloride is removed overhead and recycled to the contactor. The isomerized hydrocarbon (ca. 55% isobutane) from the bottom of the HCl stripper is washed with dilute caustic and distilled to provide isobutane for alkylation. From a corrosion viewpoint only that part of the process is of interest in which aluminum chloride or antimony trichloride is handled.

The catalyst mixture is sufficiently corrosive to carbon steel to require use of alloy equipment in some locations. The degree of corrosiveness is not as severe as that encountered in the use of aluminum chloride-hydrocarbon complex, as evidenced by the fact that satisfactory corrosion resistance has been obtained in most instances with alloys such as nickel. There is an apparent anomaly in this situation. Corrosion of carbon steel by aluminum chloride-hydrocarbon complex was inhibited effectively by addition of antimony trichloride, whereas with the fluid salt catalyst, which contains approximately 90 percent antimony trichloride, carbon steel is corroded appreciably. This may be explained as follows: In both cases antimony plates out on the steel surface with an equivalent quantity of iron going into solution; however, with the fluid salt catalyst the antimony coating is not sufficiently protective to prevent this reaction from continuing. This failure of the antimony coating may be associated with the high degree of activity of the fluid salt catalyst, or it may be analogous to situations prevailing in plating baths wherein relatively minor changes in conditions or compositions have a marked influence on the adhesion characteristics of the plated metal. Further data relating to this effect will be presented in the discussion following.

#### Corrosion Resistance of Alloys

Owing to war-time material shortages temporary use was made of carbon steel equipment in the reaction section of a butane isomerization plant. This location presents the most corrosive conditions and

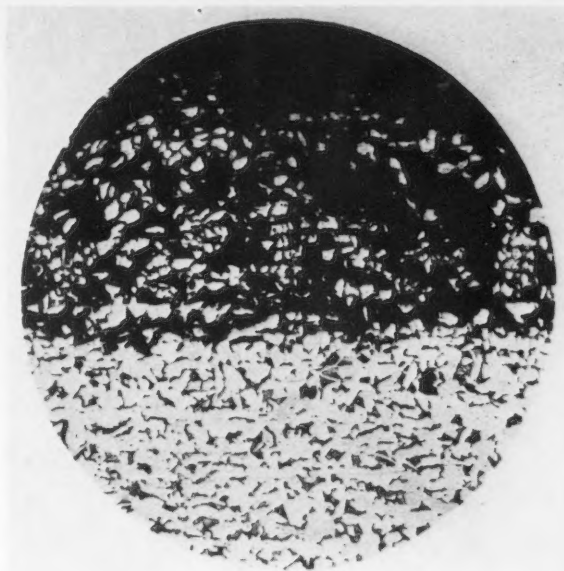


Figure 3—Photomicrograph showing intergranular nature of corrosion of carbon steel by aluminum chloride-antimony trichloride catalyst. Scale layer with imbedded ferrite grains. X100, Nital etched.

severe corrosion of the steel was observed, penetration rates being of the order of 500 to 1000 mils per year. Although fairly thick deposits of metallic antimony formed on the steel surfaces, corrosion appeared to proceed at a linear rate. Metallographic examination of corroded steel from this location disclosed that the attack proceeded uniformly over the surface along intergranular paths, grains of steel being entirely isolated from the parent metal (see Figure 3). The depth of intergranular attack was generally about 0.005 inch below the surface. Stressed areas of steel, e.g., threaded pipe joints and pipe bends, in the reactor location showed accelerated general attack, but no evidence of accelerated sub-surface attack. Initial surface condition of the steel apparently was not a factor, because similar rates of attack were observed with either sandblasted, pickled, emiered, or mill-scale surfaces.

In other parts of the system where catalyst is handled corrosion behavior has varied, being dependent upon such variables as hydrogen chloride pressure and concentration of active aluminum chloride. Detailed information on the influence of these and other variables is presented in a later section. In the catalyst column reboiler corrosion of carbon steel was observed, the intensity of attack being less than that in the reactor but sufficient to require eventual replacement with a more resistant alloy. Corrosion in the catalyst scrubber, aluminum chloride saturators, and antimony trichloride feed system was low and steel equipment would be expected to give satisfactory service life. The severity of corrosion in the various connecting lines was the same as experienced in the corresponding vessels with one exception. The carbon steel line carrying hydrocarbon feed from the catalyst scrubber to the reactor exhibited stress corrosion although general corrosion was negligible.

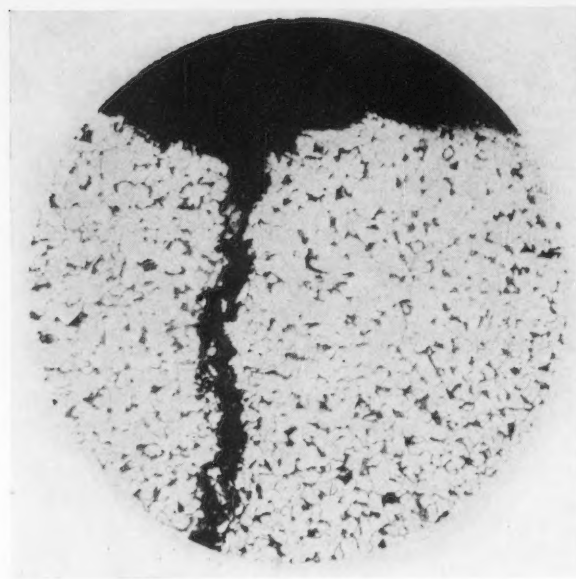


Figure 4—Photomicrograph showing intergranular stress corrosion of carbon steel in reactor feed service, butane isomerization plant. Typical crack at inner wall. X100, Nital etched.

TABLE IX. Factors Influencing Corrosion of Nickel  
by Aluminum Chloride-Antimony Trichloride Mixtures

Conditions: 60 g. 10%  $\text{AlCl}_3$ , 90%  $\text{SbCl}_3$  (c.p.) with additives as indicated. In glass test tube inside steel bomb. 90° C. 8 atm. HCl. Mild agitation. Two 0.1 x 0.5 x 2.0 in. specimens of nickel in each tube, one in liquid and one in vapor. Corrosion rates calculated from weight loss.

Exp. No.	Additive	Corrosion Rate, Mils./Yr.			
		In Liquid		In Vapor	
		0-1 Day	1-2 Day	0-1 Day	1-2 Day
1	None	5.	2.	5.	2.
2	1% $\text{SbCl}_3$	29.	<1.	84.	16.
3	Air (2 atm. air * 6 atm. HCl)	4.	..	24.*	..

\* Localized attack at liquid level line equivalent to 1000 mils./yr.

TABLE X. Corrosion of Various Alloys  
by Aluminum Chloride-Antimony Chloride Mixture

Alloy	Corrosion Rate, Mils./Yr.
<b>Laboratory Tests:</b> 1500 ml. 7% $\text{AlCl}_3$ , 93% $\text{SbCl}_3$ (c.p.) in steel vessel. System blanketed with HCl at atmospheric pressure. 90° C. Mild agitation. Duration, 1 day. Corrosion rates calculated from weight loss and are averages from duplicate specimens (5 sq. in. each).	
Carbon Steel	310.
Aluminum 525	600.
5 Cr ½ Mo Steel	46.
Type 302 Stainless Steel	8.
Type 316 Stainless Steel	3.
Monel	1.
Inconel	1.
<b>Plant Tests:</b> In catalyst exit line from butane isomerization reactor. Catalyst contained 10% $\text{AlCl}_3$ , 90% $\text{SbCl}_3$ plus traces of iron and $\text{AlCl}_3$ -hydration complex. 96° C. 300 psig. Moderate agitation. 5 days.	
Carbon Steel	990.
5% Ni Steel (SAE 2515)	16.*
Monel	0.3
Inconel	0.2
Nickel	0.0

\* 3-day test.

The process stream consisted of n-butane at ca. 70° C containing, in solution, low concentrations of hydrogen chloride, antimony trichloride and aluminum chloride. Cracks were observed at locally stressed areas, i.e. at bends and at places where bosses had been welded to the piping. Metallographic examination showed that the cracks were intergranular (see Figure 4). Stress relief annealing of the carbon steel pipe assembly after fabrication provided a satisfactory solution to this problem. Occurrence of stress corrosion cracking in this service was not surprising in view of the intergranular nature of corrosive attack by the catalyst.

In almost all locations where carbon steel suffered severe corrosion, nickel was found to be satisfactorily resistant to attack. Nickel-clad steel has been used as a material of construction for the reaction vessels and has given good service. General corrosion was very low; localized attack occurred to a minor extent, some at welds possibly due to iron contamination of the weld, and some in locations where there was a stationary gas-liquid catalyst interface. Laboratory tests (Table IX) showed that presence of oxidizing agents such as antimony pentachloride or oxygen could result in accelerated attack of nickel by the catalyst mixture. The possibility that the latter effect was responsible for the localized attack has been considered, but proof is lacking.

In certain locations where conditions of either high velocity or mild abrasion exist, e.g. control valves or pump rods, nickel was not satisfactory. This is in agreement with the proposed corrosion mechanism (see below) which indicates that nickel is protected from corrosive attack in this system by the formation of a thin adherent coating of metallic antimony. For such service *Hastelloy B* has been quite satisfactory. *Tantalum* has been used successfully as a diaphragm material for pressure gauges, and *silver* rupture discs have been used without difficulty.

Presence of metallic antimony (see below) on nickel or steel surfaces following exposure to the catalyst presented potential difficulty for subsequent welding operations. However, in practice suitable welds were obtained if precautions were taken to clean the surface carefully, e.g. by sandblasting, prior to welding.

There has been very little plant experience with other alloys, but some corrosion data were obtained in plant and laboratory tests of several alloys (Table X). Monel, Inconel, and the austenitic stainless steels appeared resistant to attack. Low alloy steels (either nickel or chromium type) showed surprisingly low corrosion rates as compared to carbon steel.

Experience with pentane isomerization was somewhat similar to the above except that severity of attack on carbon steel was generally less. With the exception of the reactor vessel and lines handling reactor catalyst, carbon steel proved satisfactory. This decreased corrosion effect can be attributed to the lower aluminum chloride content of the catalyst (see Table X).



### Factors Influencing Catalyst Corrosiveness

**Aluminum chloride concentration** was found to be an important factor in corrosion by aluminum chloride-antimony trichloride mixtures. As shown by the data of Table XI, anhydrous antimony trichloride was not very corrosive to carbon steel at 90° C. in the presence of anhydrous hydrogen chloride. However, its corrosiveness increased rapidly as the aluminum chloride content was increased. At the 10 percent value very severe corrosion was observed. Tests with samples of plant catalyst under conditions closely approximating those employed in butane isomerization showed a similar effect. Plant experience has been in agreement with these data, e.g. reduced corrosion of steel experienced in pentane isomerization as compared to butane isomerization.

Addition of water to the catalyst lowered its corrosiveness by reacting with the aluminum chloride to form the corresponding oxychloride and thus reducing the "active" aluminum chloride concentration (Table XII). In practice all feed materials are dried to reduce catalyst losses from reaction with water.

In actual plant operation a significant quantity of aluminum chloride-hydrocarbon complex or "sludge" tends to accumulate in the catalyst mixture as a result of secondary reactions of aluminum chloride with the hydrocarbon feed. In the Shell process provision is made for the continuous removal of this material from the reactor catalyst stream; hence, the concentration of complex remains at a fairly low value. Aluminum chloride in this complex form is considered inactive from the process viewpoint. Data were obtained (Table XIII) which showed that "sludging" of the catalyst mixture made the catalyst less corrosive to carbon steel. As would be expected, addition of fresh aluminum chloride to a "sludged" catalyst restored its corrosiveness. This leads to the thought that "active" aluminum chloride content is the primary chemical factor determining the corrosiveness of fluid salt catalyst. The absence of pronounced corrosion in the catalyst scrubbing column is thus explained, because in the latter location the active aluminum chloride content would be very low although the total aluminum chloride concentration is high.

**Temperature.** Corrosiveness of the catalyst mixture increased with temperature. With plant catalyst in the presence of hydrogen chloride at 1 atm. pressure this effect was pronounced, especially at temperatures above 100° C. (see Figure 5). In practice, operation is confined to a relatively narrow temperature range, 80-100° C. However, especially severe attack was observed in a small steel line carrying catalyst which was locally overheated.

**Effect of Dissolved Iron.** In laboratory tests (see Table XIV) conducted under 1 atm. HCl pressure, corrosion rates decreased rapidly with increasing time of exposure. A planned interval test<sup>6</sup> showed this effect could be attributed to decreasing corrosiveness of the catalyst mixture and not to formation of a protective coating. As was the case with the aluminum chloride-hydrocarbon complex, formation of a compound such as  $\text{Fe}(\text{AlCl}_4)_2$  is presumed to be re-

sponsible for the decreased corrosiveness of the catalyst. This effect is believed to account for the marked difference in corrosiveness in simple laboratory tests of catalyst mixtures prepared from c.p. materials and of plant catalyst samples containing the same concentration of aluminum chloride. These plant samples

**TABLE XI. Effect of Aluminum Chloride Concentration on Corrosiveness of Aluminum Chloride-Antimony Trichloride Mixture**

$\text{AlCl}_3$ Concentration, %w	Corrosion Rate, Mils./Hr.
<b>I. Conditions:</b> $\text{AlCl}_3\text{-SbCl}_3$ mixtures of various concentrations. 90° C. System blanketed with HCl at atmospheric pressure. Mild agitation. Duration, 2 days. Carbon steel specimens (60 ml. corrosive/sq. in. steel). Corrosion rates calculated from weight loss.	
0.4.....	12.
2.2.....	60.
10.....	610.
36.†.....	630.
<b>II. Conditions:</b> Reactor catalyst from butane isomerization plant. In nickel pressure vessel. 85° C. 12 atm HCl. Moderate agitation. Duration, 17-18 hr. Carbon steel specimens. (150 ml. corrosive/sq. in. steel.)	
7.....	410.
11.....	1250.

\* 1 day test at 100° C.

† Incomplete solution.

**TABLE XII. Effect of Water on Corrosiveness of Aluminum Chloride-Antimony Trichloride Mixtures**

$\text{H}_2\text{O}$ Added, %w	Corrosion Rate, Mils./Yr.
<b>A. Conditions:</b> 10% $\text{AlCl}_3$ , 90% $\text{SbCl}_3$ mixture in glass. 90° C. System blanketed with HCl at atmospheric pressure. Mild agitation. Duration, 1 day. Carbon steel specimens (12-20 ml. corrosive/sq. in. steel). Corrosion rates calculated from weight loss.	
None.....	650.
1.0.....	23.
<b>B. Conditions:</b> Reactor catalyst (11% $\text{AlCl}_3$ ) from butane isomerization plant. In nickel pressure vessel. 85° C. 12 atm. HCl. Moderate agitation. Duration, 17-18 hr. Carbon steel specimens (150 ml. corrosive/sq. in. steel).	
None.....	1250.
1.0.....	330.

Note: 1%  $\text{H}_2\text{O}$  reacting to give  $\text{AlOCl}$  is equivalent to 7.5%  $\text{AlCl}_3$  in the above.

**TABLE XIII. Influence of "Sludging" on Corrosiveness of  $\text{AlCl}_3\text{-SbCl}_3$  Catalyst to Carbon Steel**

**Conditions:**  $\text{AlCl}_3\text{-SbCl}_3$  mixtures as indicated. 90° C. System blanketed with HCl at atmospheric pressure. Mild agitation. Duration, 1 day. 16-24 ml. corrosive/sq. in. steel.

Exp. No.	Catalyst	Catalyst Pretreatment	Corrosion Rate, Mils./Yr.
1	10% $\text{AlCl}_3$ , 90% $\text{SbCl}_3$	None.....	160.
2	10% $\text{AlCl}_3$ , 90% $\text{SbCl}_3$	n-heptane + HCl at 90° C. for 4 days...	7.
3	Reactor catalyst	None.....	80., 70.
4	Reactor catalyst	Tech. octane at 90° C. for 3 hours.....	18., 17.
5	Sludged reactor catalyst	None.....	13., 15.
6	Sludged reactor catalyst	10% $\text{AlCl}_3$ added.....	170., 80.

**TABLE XIV. Planned Interval Corrosion Test of Carbon Steel in  $\text{AlCl}_3\text{-SbCl}_3$  Mixture**

**Conditions:** 10%  $\text{AlCl}_3$ , 90%  $\text{SbCl}_3$  mixture (c.p.) in glass. System blanketed with HCl under atmospheric pressure. Mild agitation. 90° C. Carbon steel specimens.

Period, Days	Corrosion Rate, Mils./Yr.
0-1.....	800.
1-2.....	300.
0-2.....	600.

as a rule contained significant concentrations (ca. 1%) of dissolved iron. In practice this effect is not very significant because it was observed only under conditions of low hydrogen chloride pressure.

**Hydrogen Chloride Pressure.** Although it appears from Table XV that the presence of hydrogen chloride is not essential to the corrosion reaction, these data show it to have an accelerating effect. Tests with carbon steel exposed to plant catalyst showed corrosiveness of the catalyst to be almost directly proportional to hydrogen chloride pressure. With plant catalyst, i.e., with catalyst samples containing ca. 1 percent dissolved Fe and a small amount of aluminum chloride-hydrocarbon complex, it is possible that high partial pressures of hydrogen chloride tend to offset the "inhibiting" action of the iron.

The possibility of reducing corrosion of carbon steel in the reaction zone by manipulation of operating conditions was investigated, but it was found this could not be done without concurrent loss of production because those factors (lowered temperature, decreased "active"  $\text{AlCl}_3$  concentration, and decreased HCl pressure) which could be expected to reduce corrosion of carbon steel were also the factors which would lower conversion of n-butane to isobutane.

### Corrosion Mechanism

In a laboratory test in which a carbon steel specimen was immersed in 10 percent  $\text{AlCl}_3$ , 90 percent  $\text{SbCl}_3$  (c.p. materials) at  $87^\circ\text{C}$ . with 1 atm. HCl pressure, the hydrogen evolved was measured and found to be less than 5 percent of that required to satisfy the following reaction:



Analyses of the solid corrosion product remaining on the metal surface following corrosion tests showed it to contain metallic antimony as the major constituent. In view of these observations, the main over-all corrosion reaction probably is:



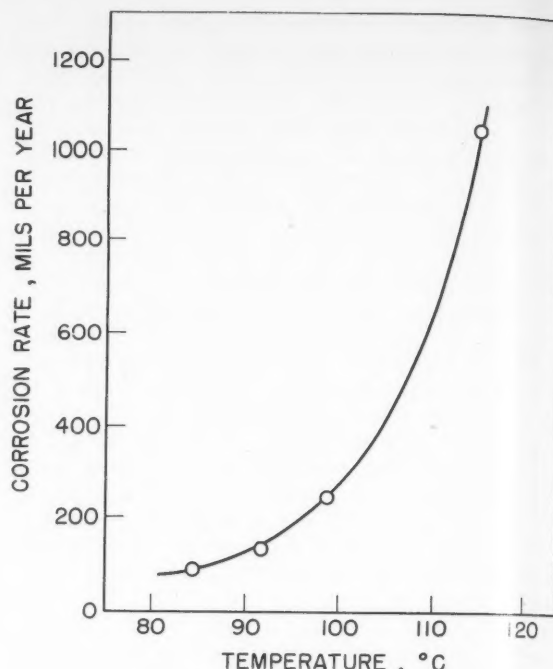
**TABLE XV. Influence of Hydrogen Chloride Pressure on Corrosiveness of  $\text{AlCl}_3$ - $\text{SbCl}_3$  Catalyst to Carbon Steel**

**A. Conditions:** Specimens of carbon steel exposed to comparable samples of reactor catalyst (11%  $\text{AlCl}_3$ ) under conditions of mild agitation. Corrosion rates calculated from weight loss.

Type of Test	HCl Pressure, Atm.	Corrosion Rate, Mils./Yr.
<b>I. Plant Test:</b>		
5 days at ca. $96^\circ\text{C}$ .	12.	990.
<b>II. Lab Test (in glass):</b>		
1 day at $92^\circ\text{C}$ .	1.	120.
<b>III. Lab Test (in nickel):</b>		
1 day at $85^\circ\text{C}$ .	12.	1250.

**B. Conditions:** 10%  $\text{AlCl}_3$ -90%  $\text{SbCl}_3$  (c.p.) in glass,  $90^\circ\text{C}$ . Stagnant. Pretreatment as indicated. Carbon steel specimen (10 ml. corrosive/sq in. surface). Duration, 15 hours.

Pretreatment	Corrosion Rate, Mils./Yr.
None	240.
HCl saturated (1 hour at $90^\circ\text{C}$ .)	460.
$\text{N}_2$ saturated (1 hour at $90^\circ\text{C}$ .)	260.



**Figure 5—Effect of temperature on corrosion of carbon steel by aluminum chloride—antimony trichloride catalyst. Conditions:** Catalyst from butane isomerization reactor (ca. 10%  $\text{AlCl}_3$ ). System blanketed with HCl gas at atmospheric pressure. Mild agitation. Duration of test 6 hours. 40 ml. corrosive/sq. in. steel surface.

In the absence of aluminum chloride, corrosion was very slight (Table XI) and it can be assumed that the reduced antimony formed a protective coating on the steel surface. With increased concentration of aluminum chloride and hydrogen chloride, the mixture became appreciably more corrosive indicating a marked change in the character of the mixture which destroyed the protective nature of the antimony coating. This change could be associated with the increased conductivity of antimony trichloride that occurs upon addition of aluminum chloride. As noted earlier preferential attack occurs at the grain boundaries. Laboratory data and plant experience have indicated that under butane isomerization reaction conditions the antimony coating formed on carbon steel has little protective value, corrosion rates being constant with respect to time. However, this tendency to form an antimony coating accounts for the high degree of corrosion resistance afforded by nickel and Monel and the surprising resistance of a low alloy steel such as SAE 2515 (5 percent nickel steel). Experience showed that light abrasion would destroy the protective action of the antimony on some alloys and lead to severe localized attack. Alloys such as Hastelloy B were required for complete corrosion resistance in these situations.

This catalyst mixture could be considered to be appreciably less corrosive in general than the aluminum chloride-hydrocarbon complex type of liquid catalyst. It is interesting to note that, except for the relative amount of constituents, this fluid salt catalyst is similar to an antimony trichloride inhibited alu-

minum chloride-hydrocarbon complex. The difference in corrosion behavior is very pronounced with carbon steel, but with other alloys the effects are quite similar.

### Inhibition

The possibility of using inhibitors to control corrosion of carbon steel in this system appears very slight in view of the limitations imposed on any potential inhibitor by 1) the need to preserve the high reactivity of the aluminum chloride, and 2) the solubility and vapor pressure properties required for any inhibitor to stay with the catalyst in its recycling operations. It was found in laboratory tests that partial inhibition could be achieved by addition of arsenious chloride. Under simulated butane isomerization conditions *ca.* 2%w As, added as  $\text{AsCl}_3$ , resulted in 85 percent or better reduction in the corrosion rate of carbon steel (Table XVI). A possible slight acceleration of attack on nickel was observed. However, use of  $\text{AsCl}_3$  as an inhibitor in this process was considered unattractive owing to 1) lack of complete inhibition, 2) high distribution ratio (*ca.* 1) between hydrocarbon and catalyst, 3) relatively high vapor pressure, and 4) extreme toxicity hazards.

### Acknowledgment

The authors acknowledge the cooperation of their colleagues in the Corrosion Department of Shell Development Company, especially the contributions of J. Schuyten and M. K. Weber. The authors are likewise indebted to H. E. Randlett of the Engineering Department for information concerning plant corrosion experience, and to W. E. Ross of the Process Development Department for process information.

TABLE XVI. Arsenic as Corrosion Inhibitor in  $\text{AlCl}_3\text{-SbCl}_3$

Test Conditions	As Conc., %w	Corrosion Rate, Mils./Yr.	
		Carbon Steel	Nickel
I. Reactor catalyst in nickel vessel. 87° C. 12 atm. $\text{HCl}$ . Mild agitation. 42 hr.	0.0	930.	11.
IA. Inhibitor added as $\text{AsCl}_3$ .....	2.4	130.	20.
II. 10% $\text{AlCl}_3$ , 90% $\text{SbCl}_3$ in glass. 90° C. System blanketed with $\text{HCl}$ gas at atmospheric pressure. Strong agitation. 22 hours.	0.	650.	3.
IIA. Inhibitor added as $\text{As}_2\text{O}_3$ .....	0.26	90.	12.
IIB. Inhibitor added as $\text{As}_2\text{O}_3$ .....	0.67	90.	12.
IIC. Inhibitor added as $\text{As}_2\text{O}_3$ .....	1.6	35.	12.

TABLE XVII. Compositions of Alloys Employed in Corrosion Tests

Alloy	Nominal Composition (%)
Carbon Steel.....	0.06-0.2 C; Fe (Several stocks employed)
4-6 Cr Steel.....	5 Cr; 0.5 Mo; Fe
5% Ni Steel (SAE 2515).....	0.1-0.2 C; 0.3-0.6 Mn; 4.75-5.25 Ni; Fe
Type 302 Stainless Steel.....	0.08-0.15 C; 8-10 Ni; 17-19 Cr; Fe
Type 304 Stainless Steel.....	0.08 max C; 8-11 Ni; 18-20 Cr; Fe
Type 316 Stainless Steel.....	0.1 max C; 1.75-2.75 Mo; 10-14 Ni; 16-18 Cr; Fe
Durimet "T".....	0.07 max C; 2 Mo; 1 Cu; 1 Si; 19 Cr; 22 Ni; Fe
Silicon Bronze.....	3 Si; 1 Mn; 96 Cu
Monel.....	67 Ni; 30 Cu; 1.4 Fe
Nickel.....	99.4 Ni
Inconel.....	79.5 Ni; 13 Cr; 6.5 Fe; 0.08 C.
Hastelloy B.....	24-32 Mo; 3-7 Fe; 0.02-0.12 C; Ni
Aluminum 52S.....	2.5 Mg; 0.25 Cr; Al

### Bibliography

1. Anon., *Petro. Ref.*, **27**, No. 9, 2 (1948) Sept.
2. C. A. Thomas, "Anhydrous Aluminum Chloride in Organic Chemistry." New York. Reinhold, 1941, p. 74.
3. N. Gragen, C. W. Nysewander and W. R. Hertwig, *Ind. Eng. Chem.*, **40**, 1133 (1948).
4. U. S. Patent 2,411,483.
5. S. H. McAllister, W. E. Ross, H. E. Randlett and G. J. Carlson, *Trans. AICHE*, **42**, No. 1, 33 (1946) Feb. 25.
6. A. Wachter and R. S. Treseder, *Chem. Eng. Prog.*, **43**, 315 (1947).

### DISCUSSION

Question by M. A. Scheil, A. O. Smith Corp., Milwaukee, Wis.:

The authors point out that carbon steels were poor in aluminum chloride and antimony chloride catalysts for isomerization. Carbon steel showed stress corrosion cracking and attack is along the carbon steel grain boundaries. The authors state that antimony forms a metallic film. They also mentioned that water vapor in the hydrocarbon stream reacts to form hydrochloric acid and causes great corrosion. The writer asks if any of the higher chromium stainless alloys had been used in the same environment.

Authors' Reply:

We have no record of any plant experience with high chromium stainless alloys in service with the  $\text{AlCl}_3$ ,  $\text{SbCl}_3$  catalyst. In laboratory tests (Table X) 4-6 Cr with  $\frac{1}{2}$  Mo, Type 302, and Type 316 were resistant to attack, and it is possible that straight chromium stainless steels would give similar results.

Questions by Leon D. Cook, Jr., Wyandotte Chemicals Corp., Detroit, Mich.:

1. Was the moisture content determined in the hydrocarbons used in this process?

2. How would moisture in the hydrocarbon feed affect the corrosion rate of metals in contact with the reaction mixture containing the complex?

Authors' Reply:

1. In butane isomerization with  $\text{AlCl}_3$ ,  $\text{SbCl}_3$  as catalyst the hydrocarbon feed was dried using activated alumina in a system capable of reducing the water content to about 0.001 weight percent.

2. Traces of water would not be expected to have any significant effect on corrosiveness of the complex. Water would react immediately with the  $\text{AlCl}_3$  present to give the corresponding oxychloride and hydrogen chloride. If a separate water phase could exist, severe corrosion would be expected wherever hydrogen chloride was present.



# Cooperative Corrosion Testing In the Wood Pulping Industry\*

By T. R. GAULKE\* and M. A. SCHEIL\*\*

THE subject matter of this paper was not designed to present an ideal corrosion testing program for plant operating equipment; nor to criticize various types of specimens or sizes or methods of mounting these specimens. It is the primary purpose of this paper to show how a cooperative corrosion testing program can be used to select the proper material for a particular job; and to show how heat treatment, welding and working this material influence its corrosion resistance and guide the equipment manufacturer in his methods of fabrication.

Cooperative corrosion testing between the wood pulping industry and the equipment manufacturer consists essentially of exposing specimens of different materials in a specific corroding medium, and for the purpose of this paper, exposures in pulp digesters and liquor heating tanks will be discussed. However simple the test, the results can be most gratifying from the standpoint of satisfactory equipment service and long life.

As a result of a considerable number of years of work along this line, the importance of certain obligations and responsibilities of each member in this cooperative effort has become apparent. In regard to the pulping mills' part of the program, three things stand out:

1. To supply some process information to the equipment manufacturer.
2. To give a materials history for the process.
3. To install test specimens in operating equipment and keep a close check on these specimens.

The process information would of course include something about the chemistry; the operating temperatures and pressures; and whether there is agitation, thermal shock, abrasion or other factors which might affect the durability of a material. It is well known, for example, that some metal alloys resist corrosion in certain media better than others, that some alloys lose their corrosion resistant properties at elevated temperatures and that some resist abrasion and thermal shock better than others. It is also well known that the so-called stainless steels are not always stainless. Hence, knowing something about the process, the equipment manufacturer can eliminate from consideration certain metals and alloys which he knows from previous experience will not withstand the service conditions of that process. A savings in time, effort and money is effected when only

those materials which presumably have the required characteristics are tested for exposure.

In many instances the experience of the pulping mill has been such that some groundwork necessary to a complete study of the corrosion conditions as they affect different materials can be eliminated. The experience gained from the use of old equipment and possibly in the repair of present equipment may have shown which materials were unsuited to the process from the standpoint of corrosion resistance or fabrication or welding. Knowing which materials are unsuitable, it is needless to incorporate them into any corrosion testing program.

Also, it is of benefit to know what corrosion characteristics are present in operating equipment. An alert observer would note whether the corrosive attack in a digester, for example, was general and widespread or whether it occurred locally. He would note whether there was general attack or pitting attack; or whether the weld metal corrodes faster than the stock; or whether there was preferential attack adjacent to the weld seams as might occur in some stainless steel equipment. He would look for cracks and note carefully their location. All these observations play a time-saving part in the selection of a suitable material for resisting corrosion and guarding against equipment failure in pulp and paper manufacture.

As stated previously, the general and sensible procedure for a cooperative corrosion testing program is to simply expose a series of test specimens to the corroding medium for a suitable period of time, then withdraw the specimens for examination. These specimens should represent judiciously selected alloys in various conditions of fabrication and treatment and it would be the mill's responsibility to install them in the proper location for corrosion testing and to safeguard them during their exposure period. An accurate accounting of the length of exposure time is imperative for calculating corrosion rates.

Figure 1 shows two pages of a test form containing questions relating to the type of information desired for these cooperative corrosion testing programs.

The equipment manufacturer's part of the program would be to:

1. Select the materials for corrosion testing.
2. Make up specimens of these materials for exposure.
3. Examine these specimens after exposure.
4. Recommend the most suitable material.

If the equipment manufacturer has a good background of experience in corrosion problems in the

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\* Research Metallurgist      \*\* Director of Metallurgical Research,  
A. O. Smith Corp., Milwaukee, Wis.

pulp and paper industry, he will be able to select a few metal alloys for testing which should indicate readily a suitable material. However, if the process is a new development, or if it is an old one with some new modifications, a more extensive program may

have to be undertaken. In any event, it may be wise to have the mill representatives and the manufacturer get together and make the selection of the alloys for testing a cooperative effort.

The equipment manufacturer also would be responsible for making up the test specimens. A. O. Smith has come to use several standard types. These are the horseshoe, the beam and the tuning fork types for stress corrosion testing. There is a cross-welded specimen to check the effect of welding and heat treating the material and there is a paddle-shaped specimen which embodies the fabrication procedures and heat treatments of a finished piece of equipment. This latter is used chiefly as a control specimen. Figures 2, 3, 4 show the procedure for making several of these specimens. The horseshoe specimen (not shown) is made similar to the beam type, except that the beam is bent across a mandrel

Return to:  
A. O. Smith Corporation  
Metallurgical Research Dept.  
Milwaukee 1, Wis.  
Attn. M. A. Schell

**RECORD OF  
CORROSION TEST EXPOSURE  
TO SERVICE PROCESS**

MS. ....  
Date .....

Company .....

Address .....

Plant where specimens were exposed .....

**Corrosion Conditions**

1. Corrosion media and concentrations .....

2. Are other corrosives apt to form from the process (e.g.,  $H_2S$ ,  $HCl$ , et al)?  
Explain .....

3. Operating temperatures: Max. .... Min. ....  
4. Operating pressures: Max. .... lb. .... Min. .... lb. ....  
5. Is water or water vapor present? If so, to what extent? .....

6. Is the process oxidizing? Reducing? Neutral? Strong? Moderate? Weak? .....

7. Is the process aerated? Extensively? Moderately? Slightly? .....

8. Is the process agitated? Is a stirrer present? R.P.M. .... Material ....  
Explain .....

9. Is there an erosive or abrasive action? Explain .....

10. Does thermal shock occur during the process? Explain .....

**Previous Equipment Experience**

1. What materials have been used in the past and with what degree of success? .....

2. What materials are being used at present and how effective are they? .....

A. O. Smith Corporation  
Metallurgical Research Dept.

**RECORD OF  
CORROSION TEST EXPOSURE  
TO SERVICE PROCESS**

MS. ....  
Date .....

3. Is welded fabrication employed? What type of welding process? What type of metal? Does corrosion occur at or near the welds? Were the welds heat treated? How? .....

4. Types of corrosion previously noted:  
Uniform attack ..... Desincrustation .....  
Pitting attack ..... Intergranular attack .....  
Galvanic attack ..... Stress corrosion .....  
Concentration cell ..... Corrosion-erosion .....

**Test Specimen Exposure Data**

1. Location of specimens (liquid or vapor, which part of process, etc.) .....

2. Time of operating cycle .....

3. Number of cycles .....

4. Total hours specimens were exposed in process (this information is necessary to calculate corrosion rates) .....

5. Condition of specimens between cycles (were they exposed to atmosphere or submerged in process and for how long?) .....

**Additional Comments** .....

Reported by .....

Company .....

Address .....

Figure 1



Figure 2—Preparation of cross-weld corrosion specimens. Specimens, left to right: 1—7/64-inch alloy liner as received 2 1/4-inch by 3 1/4-inch. 2—Cross weld of single bead alloy deposit. 3—Weld bead ground flush. Machined to 2 inches by 3 inches. 4—Finished specimen identified, sandblasted, polished with 120 grit.



Figure 3—Preparation of beam-type stress-corrosion specimens. Specimens, left to right: 1—7/64-inch alloy liner plates scarfed for welding. 2—Full penetration alloy weld. 3—Weld beads ground flush and polished with 120 grit. 4—Specimen mounted and stressed 40,000 psi.

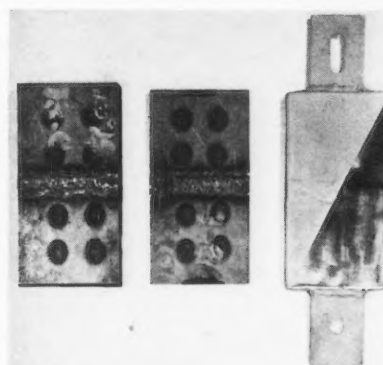


Figure 4—Preparation of corrosion test paddles. Specimens, left to right: 1—7/64-inch alloy liner spotwelded to 1/2-inch carbon steel plate. 2—Carbon steel machined to 1/4-inch overall thickness and scarfed for seal welding. 3—Finished paddle with duplex surface preparation: Sandblast and 120 grit polish.

to form a U, and a stud is passed through the holes and securely fastened to provide a predetermined stress.

Figure 5 shows two racks containing six crosswelds ready for shipment and Figure 6 shows two racks of horseshoe specimens. An entire boxed assembly is shown in Figure 7. A method of attaching specimens

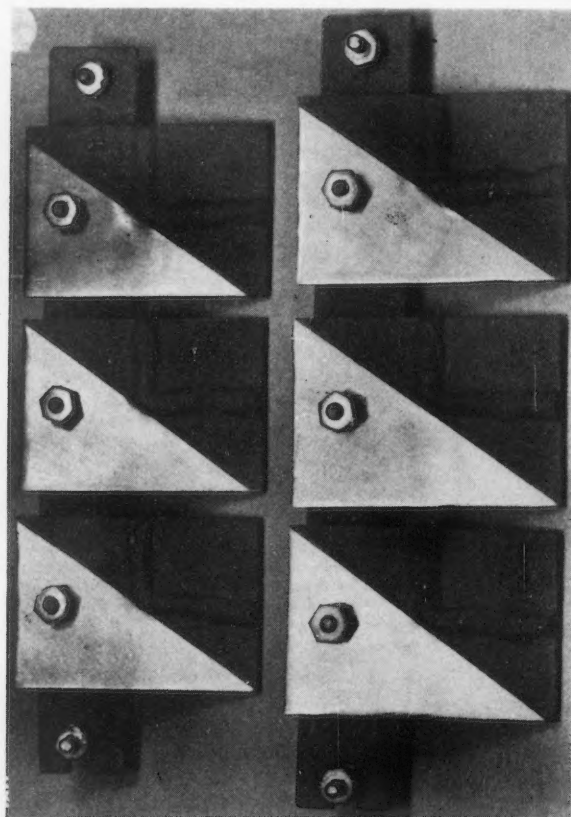


Figure 5

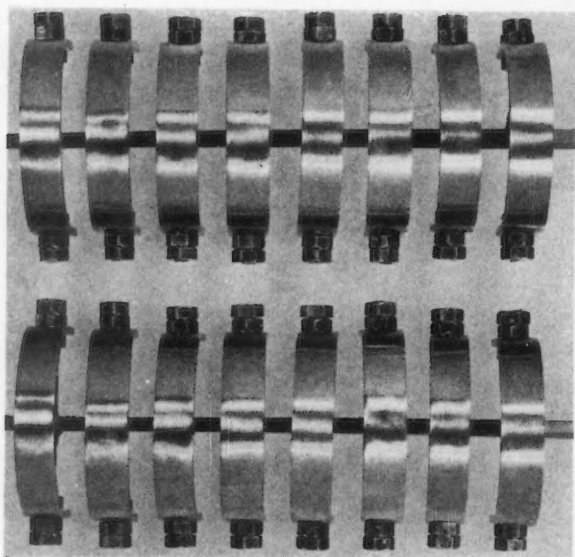


Figure 6

to the strainer screen of a digester in shown in Figure 8.

The time necessary to expose a series of test specimens will vary. Generally, it has become customary for A. O. Smith to use six months or a year exposure periods. In the case of specimens being exposed for control or progress checks in equipment built by this company, this frequency fits in well with semiannual inspection of such equipment. It usually is advisable

Figure 7—Corrosion specimens boxed for shipping.

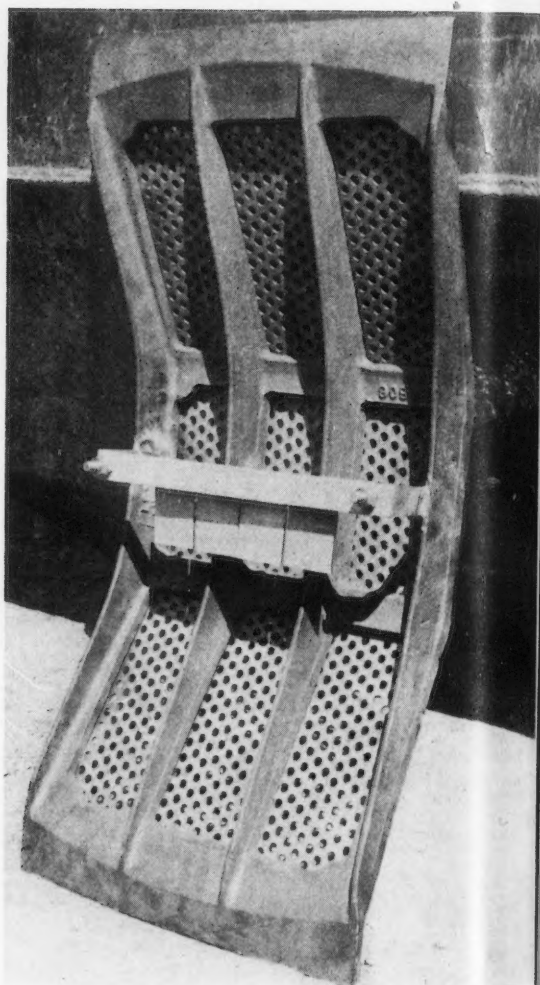
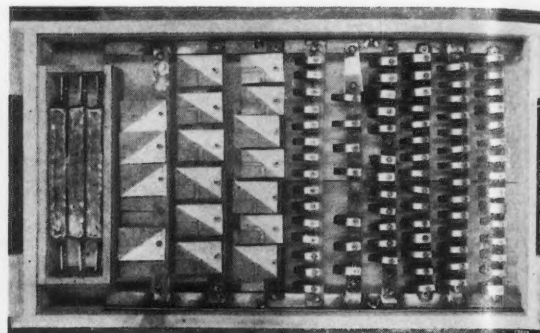


Figure 8



for exposures to be made in periods—three generally being sufficient. The specimens are examined and corrosion rates based on inches penetration per year are calculated after each period.

When all the exposure periods are completed, the specimens examined and the corrosion data calcu-

lated, a sensible comparison of the test materials can be made. The most suitable material from the standpoint of resistance to corrosion, heat treatment, cost of fabrication and other economic factors can be recommended.

In examining the results obtained from cooperative

**TABLE I—Exposure in Sulphite Digester**  
(5½% free SO<sub>2</sub> + 1% Combined SO<sub>2</sub>)

Alloy	Heat Treatment	CORROSION RATES, (Mils per Year)				
		670 Hr.	1890 Hr.	1080 Hr.	3240 Hr.	Average
316 Cb.	Mill Annealed	0.22	0.15	0.04	0.11	0.13
317	Mill Annealed	0.24	0.06	0.02	0.06	0.10
347	Mill Annealed	0.18	0.11	0.07	0.09	0.11
329	Mill Annealed	0.47	0.37	....	....	0.42
311	Mill Annealed	0.27	0.12	....	....	0.20
316 Lo C.	Mill Annealed	....	....	....	0.07	0.07
Durimet T.	Mill Annealed	....	0.12	0.02	0.12	0.09
Hastelloy C.	Mill Annealed	....	2.90	....	....	2.90

Welded Specimens						
316 Cb.	As Welded	0.22	0.13	0.17	0.07	0.15
317	As Welded	0.28	0.08	0.01	0.07	0.11
347	As Welded	0.22	0.17	0.07	0.05	0.13
329	As Welded	0.45	0.27	....	....	0.36*
311	As Welded	0.27	0.12	....	....	0.20
316 Lo C.	As Welded	....	....	....	0.08	0.08
Durimet T.	As Welded	....	0.30	0.01	0.16	0.16
Hastelloy C.	As Welded	....	10.1	....	....	10.1

NOTE: 1. Specimens exposed in digester operating with calcium bisulphite liquor at 175-290° F. and 85 lb. pressure.  
2. Specimens were of the stress-corrosion horseshoe type.  
3. Weld metal was of the same type as the alloy.  
\* Stress cracked.

**TABLE II—Exposure in Calcium Bisulphite Process**  
(5½% free and 1% combined SO<sub>2</sub>)

Alloy	Heat Treatment	CORROSION RATES, (Mils per Year)				
		670 Hr.	1890 Hr.	1080 Hr.	3240 Hr.	Average
316 Cb.	As Welded	0.59	0.19	0.17	0.13	0.27
317	As Welded	0.26	0.21	0.20	0.09	0.25
347	As Welded	0.36	0.17	0.14	0.06	0.18
329	As Welded	1.10	0.66	....	....	0.88
311	As Welded	0.84	0.30	....	....	0.57
316 Lo C.	As Welded	....	....	....	0.23	0.23
Durimet T.	As Welded	0.90	0.35	0.14	0.21	0.40
Hastelloy C.	As Welded	5.67	3.5	....	....	4.59

316 Cb.	Head forming treatment (2150° F. for 3½ hr. periods between weld deposits)	1.15	0.31	1.36	0.10	0.73
317	"	1.37	0.24	0.17	0.05	0.71
347	"	1.03	0.20	0.19	0.08	0.38
329	"	1.69	0.46	....	....	1.08
311	"	1.61	0.37	....	....	0.99
316 Lo C.	"	....	....	....	0.76	0.76
Durimet T.	"	1.67	0.26	0.20	0.42	0.64
Hastelloy C.	"	0.80	9.9	....	....	9.00

Note: 1. Specimens exposed in digester operating at 175-290° F. and 85 lb. pressure.  
2. Specimens were of the cross-weld type.  
3. Weld metal was of the same type as the alloy.

**TABLE III—Effect of Heat Treatment on 4 Alloys**  
(Calcium Bisulphite Exposure)

Alloy	Weld	Heat Treatment	CORROSION RATES, (Mils per Year)				
			(Horseshoe Specimens)				Average
316 Cb.	None	Mill Annealed	0.22	0.15	0.04	0.11	0.13
316 Cb.	316 Cb.	As Welded	0.22	0.13	0.17	0.07	0.15
316 Cb.	316 Cb.	A*	0.28	0.16	0.09	0.07	0.15
316 Cb.	316 Cb.	B*	0.39	0.12	0.10	0.08	0.17
316 Cb.	316 Cb.	C*	0.67	0.21	0.06	0.12	0.27

317	None	Mill Annealed	0.24	0.06	0.02	0.06	0.10
317	317	As Welded	0.28	0.08	0.01	0.07	0.11
317	317	A	0.24	0.13	0.05	0.05	0.12
317	317	B	0.24	0.12	0.05	0.11	0.13
317	317	C	0.38	0.14	0.09	0.15	0.19

347	None	Mill Annealed	0.18	0.11	0.07	0.09	0.11
347	347	As Welded	0.22	0.17	0.07	0.05	0.13
347	347	A	0.30	0.21	0.11	0.06	0.17
347	347	B	0.26	0.15	0.07	0.07	0.14
347	347	C	0.45	0.19	0.6	0.6	0.19

329	None	Mill Annealed	0.47	0.37	....	....	0.42
329	329	As Welded	0.45	0.27	....	....	0.36
329	329	A	1.22	0.62	....	....	0.92
329	329	B	0.67	0.37	....	....	0.52
329	329	C	0.98	0.43	....	....	0.71

\* Heat Treatments: (Specimen preparation)

A. Arc weld, 2100° F. for 3½ hour periods, from—  
B. 2100° F. for 3½ hour periods, arc weld, form  
C. Arc weld, form, 2100° F. for 3½ hour periods.

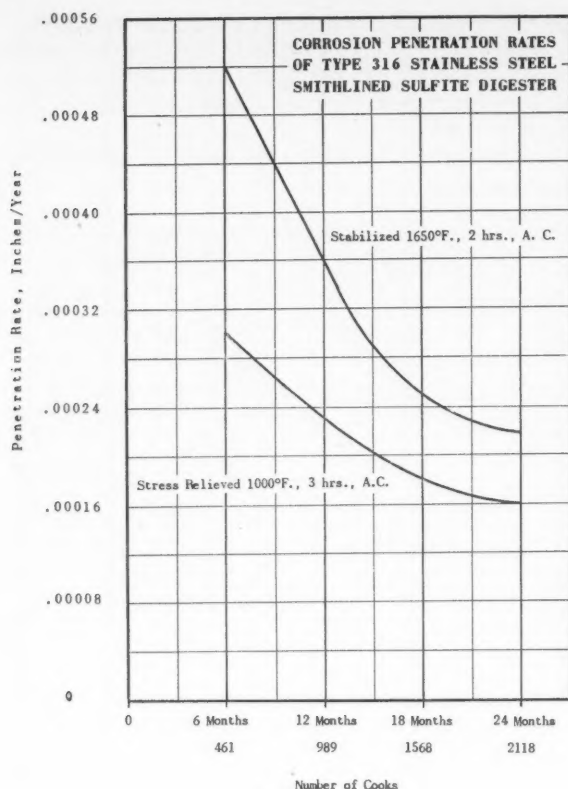


Figure 9

corrosion testing programs classifications have been made according to sulphite and sulphate exposures.

### Sulphite Exposures

Tables I, II, III show the results of exposure in a sulphite digester operating at 175-290° F and 85 lb pressure. Sulphur dioxide was given as 5½ percent free SO<sub>2</sub> and 1 percent combined SO<sub>2</sub>. Of the eight alloys tested in Table I only Hastelloy C has an excessively high corrosion rate. It is also noted that Type 329 is subject to stress-corrosion cracking. In this case Type

329 and Hastelloy C probably would be eliminated from further consideration as suitable materials. However, if it were found necessary to use Type 329 in fabricating a piece of equipment, it undoubtedly would be necessary to fully anneal the finished product in order to diminish the possibility of stress-corrosion cracking in service. No particular difference in corrosion rates between unwelded and welded specimens can be noted with the possible exception of Hastelloy C which has a corrosion rate about twice as great in the welded condition.

Table II shows the effect of a simulated "head forming treatment" on these same alloys in the welded condition. In all cases this treatment increases the corrosion rates noticeably. It could be expected then that in fabricating a digester the corrosion rates would be higher in the "hot formed" heads. In cases where the rates are seriously high, a thicker lining may be called for in the heads.

Because heat treatment of the alloys will affect corrosion rates, various treatments should be examined more closely. Table III compares five different treatments for three suitable and one unsuitable alloy. The 316 Cb, 317 and 347 alloys show a slight increase in corrosion for treatment C. Type 329 stainless has rates which are relatively too high and heat treatment does not seem to offer any improvement.

From the results of Tables I, II and III it appears that types 316 (with or without Cb), 317, 347, 311 and Durimet T, based on corrosion rates alone, would be suitable for this service. However, on the basis of surface inspection and microexamination, others of these alloys may be eliminated due to unsightly pitting, marked preferential attack, intergranular attack or cracking. Which alloy finally would be selected then as the material for a digester lining is based on the consideration of a variety of corrosion factors. In addition, where a choice of suitable alloys remains after corrosion testing, economic factors such as cost and availability of material, fabrication properties and weldability must be considered.

Table IV shows the corrosion rates on Type 316 with low carbon for three periods of exposure in a

TABLE IV—Calcium Bisulfite Process (10% SO<sub>2</sub>)

Alloy	Heat	Weld	Specimen	Heat Treatment	CORROSION RATES (Mils per Year)			
					6 Months	12 Months	18 Months	Average
(L.C.*) 316	1X5548	310 Mo	Crossweld	Stabilized 1650° F.	0.5	0.30	0.22	0.34
316	1X5549	310 Mo	Crossweld	Stabilized 1650° F.	0.6	0.37	0.32	0.43
316	2X4981	310 Mo	Crossweld	Stabilized 1650° F.	0.5	0.31	0.25	0.35
316	2X4982	310 Mo	Crossweld	Stabilized 1650° F.	0.5	0.4	0.26	0.39
316	2X4983	310 Mo	Crossweld	Stabilized 1650° F.	0.5	0.42	0.23	0.38
316	1X5548	310 Mo	Crossweld	Stress Relieved 1000° F.	0.3	0.22	0.17	0.23
316	1X5549	310 Mo	Crossweld	Stress Relieved 1000° F.	0.3	0.27	0.18	0.25
316	2X4981	310 Mo	Crossweld	Stress Relieved 1000° F.	0.3	0.22	0.18	0.23
316	2X4982	310 Mo	Crossweld	Stress Relieved 1000° F.	....	0.25	0.20	0.23

### Laboratory HNO<sub>3</sub> Tests

Alloy	Heat	Weld	Heat Treatment	CORROSION RATES (Mils per Year)					
				9	12	14	19	24	18
316 (L.C.*)	1X5548	310 Mo	Stabilized at 1650° F.	9	12	14	19	24	18
316 (L.C.*)	1X5548	310 Mo	Stress Relieved at 1000° F.	9	11	19	26	39	21
316 (L.C.*)	1X5549	310 Mo	Stabilized at 1650° F.	8	11	14	17	23	15
316 (L.C.*)	1X5549	310 Mo	Stress Relieved at 1000° F.	9	9	13	19	21	14
316 (L.C.*)	2X4981	310 Mo	Stabilized at 1650° F.	12	17	27	36	45	17
316 (L.C.*)	2X4981	310 Mo	Stress Relieved at 1000° F.	10	11	15	18	22	15
316 (L.C.*)	2X4982	310 Mo	Stabilized at 1650° F.	12	14	21	30	34	22
316 (L.C.*)	2X4982	310 Mo	Stress Relieved at 1000° F.	12	15	20	25	28	20
316 (L.C.*)	2X4983	310 Mo	Stabilized at 1650° F.	13	16	19	27	38	18
316 (L.C.*)	2X4983	310 Mo	Stress Relieved at 1000° F.	9	10	14	18	24	15

\* (L.C.)—Low Carbon (0.03 percent max.).

digester using calcium bisulphite liquor with 10 percent total SO<sub>2</sub>. This digester was built by the A. O. Smith Corporation and lined with Type 316 material from heats as listed in the table. For comparison, laboratory HNO<sub>3</sub> rates are shown on several of the heats used for fabrication. These laboratory rates were considered satisfactory. However, it is by no means justifiable to assume that when the HNO<sub>3</sub> rates are satisfactory, the service rates will also be satisfactory. Our laboratory HNO<sub>3</sub> tests are used only as a standard of quality to compare the various heats of a material prior to fabrication. It also will be noted in this table that the rates for the stabilizing heat treatment are higher than for the stress relieving treatment, and that the rates decrease for successive periods as shown by Figure 9.

In Table V are compared the corrosion rates for simultaneous exposure in a sulphite digester and in a sulphite liquor heating tank. As might be expected, corrosion is more severe in the heating tank. Stainless Type 348\* was the only alloy in the first exposure which did not show this marked difference. Again, the head forming heat treatment exhibited the higher corrosion rates, and a pronounced drop in corrosion for the second and third periods also was noted.

Seven horseshoe type specimens of five different alloys after 12,000 hours of exposure in sulphite service are pictured in Figure 10. Pitting attack is noticeable in Types 310, 316 + Cb, Sb and 304 Sb. The reason for pitting in 316 + Cb Sb is probably due to the low molybdenum content. This is more readily shown in Figure 11 where this same alloy with about 2 percent molybdenum is relatively free from pitting.

Figure 12 shows a section from a digester strainer plate which had cracked in service. The small cracks radiating from the holes at the left were found to be typical of stress-corrosion failure. Evidently the holes were punched in the plate, causing a substantial amount of cold work and stress in the adjacent metal. Failure to anneal the finished plate and thus relieve the stresses resulted in stress-corrosion cracking in service.

### Sulphate Exposures

In sulphate pulping, unlined carbon steel digesters have found considerable use. However, because of certain recent process changes which impose more stringent requirement on the carbon steel, this

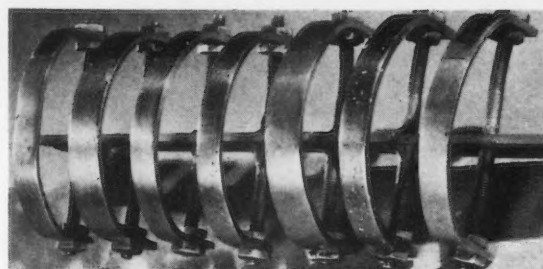


Figure 10—Specimens, (25-20): Type 310 (left); Type 310 (25-20); Type 310 (Hr. treat.); Type 316 (L.C.) (18-8 Mo); Type 316 + Cb, Sb. (1.5% Mo); Type 329 (High Cr); Type 304 + Sb (18-8 Sb); Type 309 + Mo, Cu (1% Mo).

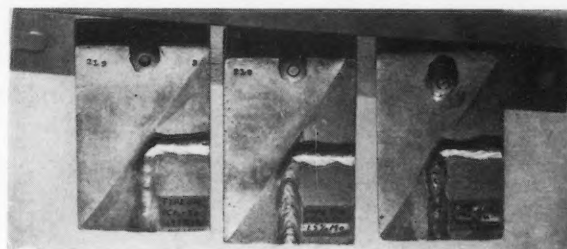


Figure 11

material has resulted in shorter life. When replacement of the old digesters is necessary, it would be well to know what materials better fit the corrosion requirements of the newer processes. Corrosion tests have been conducted in carbon steel digesters to learn something about the corrosion conditions operating there. For this work a welded carbon steel specimen about 3/4 inch square and 6 inches long was developed. Stainless steel pins usually are driven into the specimen to serve as gage points for making a direct measurement of corrosion penetration. Figure 13 shows two views of such a specimen ready for exposure.

The results of exposing carbon steel specimens welded with nine different compositions are shown in Table VI. The corrosion rates are expressed as *preferential weld attack*. In all instances but one (AWS E6010, repair) the weld shows greater attack than the stock. The use of small alloy additions to the weld metal offers no improvement.

The use of submerged arc welding on three grades of carbon steel is shown in Table VII. Steel A70 welded with Oxweld 36 seems to show the best corro-

\* Chromium content—18% min.

TABLE V—Corrosion Rates in Digester and Liquid Heating Tank (Sulfite)

Alloy	Weld	Spec. Type	Heat Treatment	Location	Corrosion Rates (Mils per Year)		
					530 Hr.	915 Hr.	880 Hr.
348	348	Horseshoe	Stress Relieved	Digester	0.33	0.11	0.03
348	348	Horseshoe	Stress Relieved	Heater	0.28	0.11	0.03
348	348	Horseshoe	Hd. form. & Stress Relieved	Digester	0.45	0.16	0.10
348	348	Horseshoe	Hd. form. & Stress Relieved	Heater	0.48	0.11	0.07
316 Cb	316 Cb	Horseshoe	Stress Relieved	Digester	0.30	0.09	0.06
316 Cb	316 Cb	Horseshoe	Stress Relieved	Heater	0.45	0.13	0.05
316 Cb	316 Cb	Horseshoe	Hd. form. & Stress Relieved	Digester	0.37	0.04	0.12
317	317	Horseshoe	Hd. form. & Stress Relieved	Heater	0.51	0.13	0.18
317	317	Horseshoe	Stress Relieved	Digester	0.17	0.10	Nil
317	317	Horseshoe	Stress Relieved	Heater	0.57	0.04	0.11
317	317	Horseshoe	Hd. form. & Stress Relieved	Digester	0.22	0.08	0.03
317	317	Horseshoe	Hd. form. & Stress Relieved	Heater	0.36	0.20	0.02
329	329	Horseshoe	Stress Relieved	Digester	0.88	0.41	0.15
329	329	Horseshoe	Stress Relieved	Heater	3.09	1.18	1.26
329	329	Horseshoe	Hd. form. & Stress Relieved	Digester	4.41	0.76	cracked
329	329	Horseshoe	Hd. form. & Stress Relieved	Heater	6.98	3.54	1.69

1 3/4% combined and 3 1/4% free SO<sub>2</sub>.

250-280° F.

60 psi.



TABLE VI—Exposure of Carbon Steel Specimens in Sulfate Digester

Alloy	Weld	Heat Treatment	Preferential Corrosion Rate on Welds (Mils per Year 10 <sup>3</sup> )	
			9 Months	12 Months
A70.....	AWS E6030	Stress Relieved 1150° F.	02.2	16.0
A70.....	AWS E6020	Stress Relieved 1150° F.	01.8	13.0
A70.....	AWS E7020	Stress Relieved 1150° F.	02.5	23.0
A70.....	AWS E7020 (V)	Stress Relieved 1150° F.	02.7	24.0
A70.....	AWS E6010	Stress Relieved 1150° F.	02.2	14.0
A70.....	AWS E6013	Stress Relieved 1150° F.	09.0	45.5
A70.....	AWS E6012	Stress Relieved 1150° F.	02.2	.....
A70.....	AWS E8020	Stress Relieved 1150° F.	05.9	+7.0
A70.....	AWS E6010	Repair Weld	.....	23.5
A70.....	AWS E7010	Repair Weld	.....	23.5
A70.....	AWS E6013	Repair Weld	.....	29.5

Nominal Analyses of Weld Metal

	C	Mn	Si	
AWS E6030.....	.07-.12	.35-.55	.15-.30	
AWS E6020.....	.07-.12	.25-.55	.15-.30	
AWS E7020.....	.07-.12	.35-.60	.10-.30	.40-.60 Mo
AWS E7020 (V).....	.07-.12	.35-.60	.10-.30	.40-.70 Mo .04-.07 V
AWS E6010.....	.07-.12	.25-.55	.15-.30	
AWS E6013.....	.07-.12	.35-.60	.10-.30	
AWS E6012.....	.07-.12	.25-.55	.15-.30	
AWS E8020.....	.07-.12	.35-.60	.10-.30	.20-.40 Cr 1.30-1.50 Ni .15-.30 Mo
AWS E7010.....	.07-.12	.35-.60	.10-.30	.40-.60 Mo

Test Conditions: 50% White Liquor 50% Black Liquor

350° F..... 143 g/l active alkali 86 g/l total alkali  
 136 lb. pressure..... 204 g/l total alkali

TABLE VII—Exposure of Carbon Steel Specimens in Sulfate Digester

Alloy	Weld	Heat Treatment	Corrosion Rates (Mils per Year 10 Months)	
			Entire Bar	Weld Only
A70.....	Oxweld 36.....	As Welded.....	0.38	0.04
A70.....	Oxweld 36.....	Stress Relieved, 1200° F.....	0.19	0.20
A89.....	Oxweld 36.....	As Welded.....	2.20	3.20
A89.....	Oxweld 36.....	Stress Relieved, 1200° F.....	0.50	0.80
A212.....	Oxweld 40.....	As Welded.....	0.88	0.30
A212.....	Oxweld 40.....	Stress Relieved, 1200° F.....	3.72	8.60

## ANALYSES

	C	Mn	P	S	Si
A70.....	.14	.43	.010	.029	.05
Oxweld 36.....	.12	.69	.025	.025	.43
A89.....	.08	.38	.010	.027	.01
Oxweld 36.....	.08	.75	.019	.022	.25
A212.....	.28	.76	.031	.031	.20
Oxweld 40.....	.20	.80	.031	.014	.39

## TEST CONDITIONS

Total exposure time..... 6215 hr.  
 Maximum operating temperature..... 350° F.  
 Maximum operating pressure..... 121 psi.  
 58% white liquor  
 42% black liquor  
 NaOH..... 55 g/l  
 Na<sub>2</sub>S..... 27 g/l  
 Na<sub>2</sub>CO<sub>3</sub>..... 33 g/l

TABLE VIII—Exposure of Carbon Steel Specimens in Sulfate Digester

Alloy	Weld	Heat Treatment	Corrosion Rates (Mils per Year) (Preferential Attack of Weld)		
			135 Days	84 Days	330 Days
A70.....	AWS E6030.....	Stress Relieve 1150° F.....	35	35	18
A70.....	AWS E6020.....	Stress Relieve 1150° F.....	60	28	6
A70.....	AWS E7020.....	Stress Relieve 1150° F.....	65	26	1
A70.....	AWS E7020 (V).....	Stress Relieve 1150° F.....	60	39	5
A70.....	AWS E8020.....	Stress Relieve 1150° F.....	46	+7	18
A70.....	AWS E6010.....	Stress Relieve 1150° F.....	57	33	3
A70.....	AWS E6012.....	Stress Relieve 1150° F.....	19	24	2
A70.....	AWS E6013.....	Stress Relieve 1150° F.....	78	41	.....
A70.....	AWS Oxweld 36.....	Stress Relieve 1150° F.....	.....	.....	42
A70.....	AWS None.....	Stress Relieve 1150° F.....	.....	20	22

Exposure Conditions: 190-350° F. 0-120 lb. pressure.

	Wood Species	Percent of Cooks	Average Charge of Active Alkali
1st period.....	Cedar.....	92.5	4200 lb. as Na <sub>2</sub> O
	Hemlock.....	4.5	4475
2nd period.....	Cedar.....	91.4	4200
	Hemlock.....	6.4	4450
	Fir.....	2.2	4500
3rd period.....	Cedar.....	50.5	4180
	Hemlock.....	40.4	4490
	Fir.....	9.1	4650

57% white liquor  
 43% black liquor

sion resistance. Corrosion rates for the as-welded condition of A212 are considerably lower than for the stress relieved condition. Figure 14 shows these specimens after exposure. In comparison we have Figure 15 which shows three submerged arc welded specimens of carbon steel after about 7000 hours of exposure in the liquid phase of a Kraft carbon steel digester operating at 212-350° F and 110 psi maximum. The top specimen is of ASTM-A212 steel welded with Oxweld 40 and exposed in the "as-welded" condition. The other two specimens are of ASTM-A70 welded with Oxweld 36. The center one was exposed "as welded" and the bottom one "as stress relieved." The notch shown to the left of the weld in the center specimen resulted mainly from this particular piece resting on a supporting bracket. Needless to say, the corrosion rates were very high on all of these specimens.

Three exposure periods for carbon steel welds are shown in Table VIII. Corrosion rates are higher than those shown on the previous tables. The relatively lower rates for the third period may be a result of the difference in charge to the digester. Generally, the corrosion rates for carbon steel specimens using various weld metals and heat treatments are unpredictable.

A comparison of carbon steel and stainless steel corrosion rates in a sulphate digester is shown in Table IX. The advantage of using stainless steel for this service is markedly shown.

Exposures of stainless steel at the top and bottom of a sulphate liquor heating tank are shown in Table X. Conditions at the top of this tank are from two to ten times as corrosive on these alloys as at the bottom. Erroneous conclusions in regard to corro-

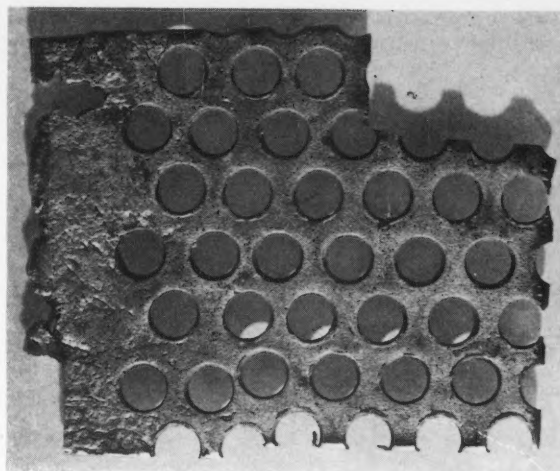


Figure 12

sion in this tank probably would be reached if these specimens were exposed in the liquid at the bottom only.

Figure 16 shows a stainless liner sleeve from an acid heating tank distributor system which failed in service. The tube portion was fabricated of Type 304 and the flange of 347. Cold forming and welding produced residual stresses in the tube which were not removed by annealing. When the part was put in service stress-corrosion cracking resulted. In addition the weld zone of the tube was found to be sensitized by the heat of welding.

In conclusion a few precautions and a word of warning should be given:

TABLE IX—Comparison of Carbon Steel and Stainless Steel Corrosion Rates in Sulfate Digester

Metal	Weld	Specimen	Heat Treatment	Corrosion Rate (Mils per Year)
405	AISI 309 Cb.	Crossweld	Stress Relieved 1150° F.	4.6
347	AISI 309 Cb.	Crossweld	Stress Relieved 1100° F.	87
315	AISI 310 Mo.	Crossweld	Stress Relieved 1000° F.	.91
A70	Oxweld 3'	Crossweld	Stress Relieved 1150° F.	108
415	AISI 309 Cb.	Horseshoe	Stress Relieved 1150° F.	1.1
A70	Oxweld 36	Horseshoe	Stress Relieved 1150° F.	171

NOTE: Specimens exposed in a carbon steel digester for 163 hours.

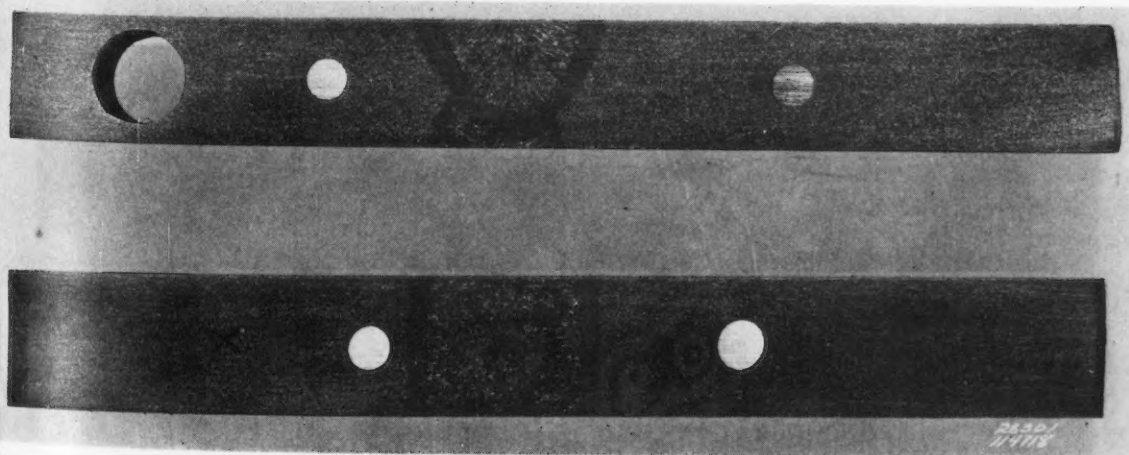


Figure 13

TABLE X—Exposure in Carbon Steel Sulfate Liquor Heating Tank

Alloy	Weld	Spec. Type	Heat Treatment	Location	Corrosion Rate (Mils per Year) 1175 Hours	
430	430	Horseshoe	Annealed	Top	0.82	2X
430	430	Horseshoe	Stress Relieved	Bottom	0.41	
430	430	Crossweld	Annealed	Top	1.16	2X
430	430	Crossweld	Stress Relieved	Bottom	0.66	
329	329	Horseshoe	Stress Relieved	Top	0.33	10X
329	329	Horseshoe	As Welded	Bottom	0.03	
329	329-309	Crossweld	Stress Relieved	Top	0.7	8X
329	329-309	Crossweld	As Welded	Bottom	0.09	
316 Cb	316 Cb	Horseshoe	As Welded	Top	5.47	8X
316 Cb	316 Cb	Horseshoe	As Welded	Bottom	0.73	
316 Cb	316 Cb	Horseshoe	Stress Relieved	Top	6.28	9X
316 Cb	316 Cb	Horseshoe	Stress Relieved	Bottom	0.68	
Inconel	Inconel	Horseshoe	As Welded	Top	1.62	8X
Inconel	Inconel	Horseshoe	As Welded	Bottom	0.20	
Inconel	Inconel	Horseshoe	Stress Relieved	Top	1.3	6X
Inconel	Inconel	Horseshoe	Stress Relieved	Bottom	0.22	
Monel	Monel	Horseshoe	Stress Relieved	Top	3.29	8X
Monel	Monel	Horseshoe	As Welded	Bottom	0.39	

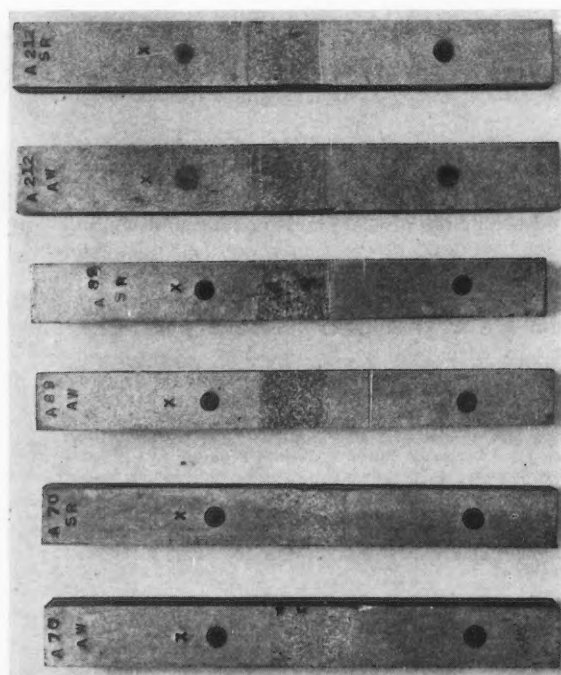


Figure 14

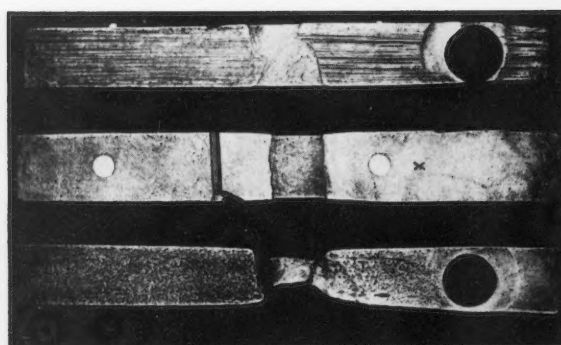


Figure 15—Submerged arc welded specimens exposed in liquid phase of carbon steel sulphate digester for 7000 hours. Top—ASTM—A212 and Oxweld 40, as welded. Center—ASTM—A70 and Oxweld 36, as welded. Bottom—ASTM—A70 and Oxweld 36, stress relieved.

First, it is important that the true corrosion conditions be evaluated. That is to say, it must be certain that specimens are exposed in that medium which is likely to cause damage by the forces of corrosion. For example, exposing specimens in a liquid phase may give misleading results when it turns out that the vapor phase or liquid-vapor interface is more corrosive.

Second, in the selection of the most suitable material from the test results, it should carefully be noted what effect welding, forming and heat treatment had on the corrosion resistance of this material; and, where there is a choice of suitable materials, that economic factors will play an important part.

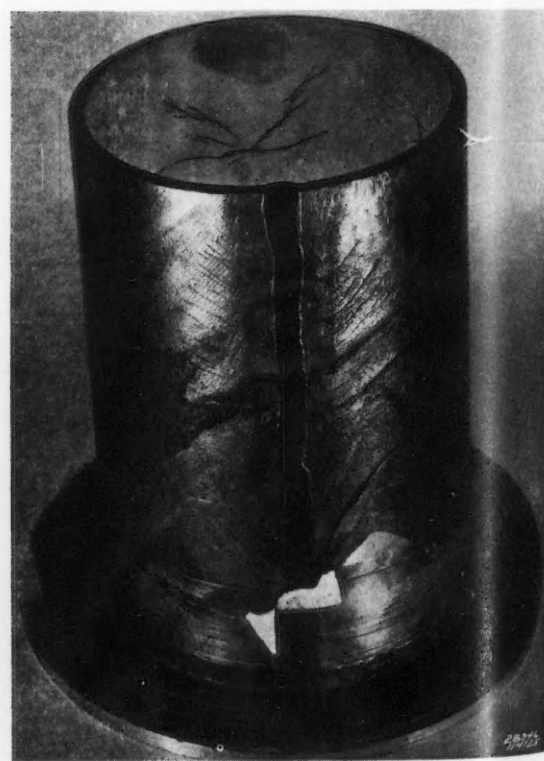


Figure 16



Third, it is most important to note accurately the number of hours the specimens are exposed because these data are necessary to calculate corrosion rates. Care should be taken to insulate corrosion specimens from contact with other metals to avoid contact corrosion and galvanic effects and subsequent misleading results.

Last, after equipment has been built and put in operation, close attention must be given to possible process changes. A change in the process also should be considered in the light of the effect this change will have on the operating equipment. Process changes may inaugurate conditions which will cause a corrosive attack on otherwise satisfactory equipment materials.

It seems most corrosion problems center about two chief methods of solution:

1. Finding the right material to withstand the corrosion.
2. Changing the process conditions to eliminate the corroding influences.

Because the second solution is applicable infrequently, it becomes necessary to find the right material. It would be convenient, to say the least, to be able to select the right handbook and choose materials from it on the basis of corrosion resistance. But because that stage has not yet been reached, the only sensible thing that remains is for each one to do his own materials testing. Much can be accomplished by work on a cooperative basis.

### DISCUSSION

Questions by J. O. Shelby, The Black-Clawson Co., Hamilton, Ohio:

Doctor Whitney, in his paper "Major Corrosion Problems in the Pulp and Paper Industry," mentioned that quite a few instances of contact or crevice corrosion had been reported under the gaskets of stainless steel pulp and paper stock lines.

I asked a question during the discussion period as to what type of gasket materials had been found to be the most damaging and which types gave the least trouble. At that time, no one was prepared to offer any comments on the above question.

We manufacture paper and pulp mill machinery and equipment and would desire any information the Association may have pertaining to this field. Of major interest at the present time are protective coatings; we have just recently begun a series of laboratory and field tests in connection with this phase. We would be happy to cooperate with the Association in any of its activities connected with our field of manufacturing. There appears to be a definite lack of information on corrosion in the pulp and paper field and we hope that the Association will extend its work in this direction.

Reply by M. A. Scheil:

I believe Mr. J. O. Shelby's question was directed to the general assembly at this symposium in an effort to solicit information from anyone present who may have had experience with gasket materials.

Since our work at A. O. Smith Corp. relating to the pulp and paper industry is not concerned with such materials, we were not in a position to offer comments.

Question by Beaumont Thomas, Stebbins Engineering & Mfg. Co., Watertown, N. Y.:

To what extent might one expect loss of thickness of the stainless clad lining due to mechanical wear alone and independent of any chemical corrosion?

Reply by M. A. Scheil:

While no direct measurements of mechanical wear along have been made the following experience is offered to shed some light on the subject. Two strips, 7/64-inch by 1/2-inch by 5 inches, of low carbon Type 316 material were welded inside the cone section of a digester lined with the same material. Welding attachment was at the ends of the specimens and in such a manner that the specimens were about 1/4-inch from the cone wall, thus permitting circulation on all sides. These specimens were previously stabilized at 1650° F for two hours and polished to a 120 grit Aloxite finish. Micrometer readings were taken over the center two inches and the average of seven readings were compared before and after exposure thus:

Specimen	Thickness Before Exposure	Thickness After 21 Mo. Exposure
A	.105 in.	.105 in.
B	.104 in.	.1035 in.

It should be mentioned also that the specimens showed their original bright luster after exposure and, hence, no cleaning operations were performed on them. The above data show essentially no change in thickness measurement; whatever difference exists lies within the range of error in measurement. If one were to use .0005-inch decrease in thickness, a corrosion penetration rate of about .00015 inch per year could be calculated. This figure compares with the lowest rates we have obtained on specimens of the same material exposed behind the strainer screen of this same digester where practically no abrasive wear is encountered. Undoubtedly the smoothness of the 120 Aloxite finish has a bearing on the lack of abrasive wear since it was thought at one time that the cone section of this digester was showing wear, and subsequent polishing of the inner cone surface eliminated this condition.

Question by J. J. Heger, Carnegie-Illinois Steel Co., Pittsburgh, Pa.:

Mr. Scheil has shown a correlation to exist between the results of corrosion tests in boiling 65% nitric acid and the results of plant corrosion tests in a sulphite digester. However, all of the materials tested by Mr. Scheil exhibited low corrosion rates in boiling 65% nitric acid. Does Mr. Scheil have any data which would show a correlation between plant corrosion tests and the nitric acid test for those 18-8 Mo ma-

terials which exhibit high corrosion rates in boiling 65% nitric acid?

Reply by M. A. Scheil:

In answer to Mr. Heger's question we have the following data to present on 18-8 Mo type alloys:

No.	Heat Treatment	Huey Rate (IPY)	Field Test Rate (IPY)		
			3192 Hr.	3252 Hr.	4812 Hr.
U-2	1000° F., 3 hr., F.C. +	.008	.000314	.000103	.000117
V-2	1625° F., 2 hr., "	.010	.000331	.000101	.000143
Y-2	" " "	.179	.000460	.000262	.000548
Z-2	" " "	.162	.000387	.000183	.000404
A	1625° F., 2 hr., "	.010	.000424	.000095	.000147
K	" " "	.186	.000392	.000090	.000136
K-5	1250° F., 2 hr., F.C., "	.140*	.000133	.000109	.000116
J-5	2100° F., W.Q. + 1250° F., 2 hr., "	....	.000544	.000189	.00318

\* Average for four periods only.

The Huey rates listed represent the average of five 48-hour periods in boiling 65% nitric acid. Field tests were conducted for three exposure periods in a ceramic brick lined digester in sulfite service.

The higher nitric acid rates can be related to slightly higher field test rates for specimens Y-2 and Z-2 when compared with U-2 and V-2 with the same heat treatment. This is particularly noticeable

for the third exposure period. A correlating difference between nitric acid rates and field rates for specimens A and K cannot be noted to date. Specimen K-5 with a high Huey rate cannot be said to have a correspondingly high field rate; while No. J-5, for which no Huey rate is shown but which showed up poorly in a Strauss test, has high field corrosion rates.

Since some of the above specimens represent experimental alloys, an analysis of the more important elements are as follows:

No.	C	Cr	Ni	Mo	Ti
U.....	.03	18.1	12.3	2.8	....
V.....	.03	18.0	12.2	2.8	....
Y.....	.05	18.3	11.9	3.4	.21
Z.....	.04	17.5	13.5	2.9	.16
A.....	.05	16.8	12.0	1.7	....
K.....	.02	17.4	12.3	2.8	....
J.....	.08	16.6	11.8	2.1	.41

It can be noted that the titanium bearing alloys possess high field corrosion rates. It was also noted during the course of field testing that those alloys which showed intergranular attack due to sensitization on nitric acid tests also showed intergranular attack on field tests. The length of time necessary for this attack to become evident on field testing can be unusually long, however.

## DISCUSSIONS ARE INVITED

Readers who wish to submit written information additive to articles published in CORROSION, or who wish to register differences of opinion with respect to any articles are urged to send such discussions to Dr. F. N. Alquist, Chairman, NACE Editorial Review Committee, Organic Research Laboratories, 20A Building, Dow Chemical Co., Midland, Mich. Doctor Alquist will submit such discussions to a member of the review committee, and after review and approval the discussion will be published.

The expression of opinions about or the addition of information to that contained in technical articles will advance the interests of NACE and make CORROSION more valuable to the membership.

## Proper Bonding of Power Cable Sheath Guards Against Galvanic Corrosion

By W. D. SANDERSON\*

ONE OF THE MAJOR duties of the corrosion engineer of any power utility is to protect the lead sheaths of all cables against the possible harmful action of stray or induced currents. It is standard practice with many companies to bond the sheaths of all cables in the same conduit, with copper wires of ample current-carrying capacity, at every manhole. This serves to prevent serious differences in potential among the lead sheaths of cables in the same conduit and affords the return current a metallic path to the station in event of a cable failure. Incidentally, the dissipation of signal currents over the sheaths of adjacent cables is of material assistance in the location of faults. Grounding of these groups of cables in manholes, however, is of doubtful benefit.

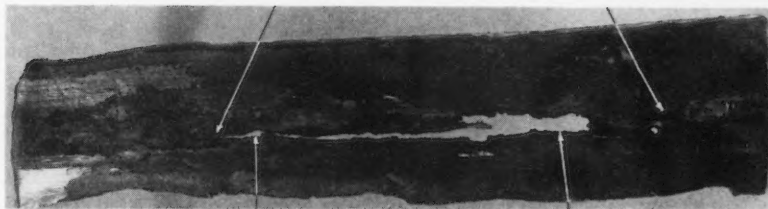
The presence of these two dissimilar metals, copper and lead, in close proximity, form the plates of a galvanic cell which is completed when the plates are placed in moist surroundings. This usually results in the deterioration of the lead sheath.

Numerous bond connections had been made on the underground cable system of The Detroit Edison Company previous to the time that any particular attention was directed toward proper bonding methods. After suffering four cable fail-

\*Cable Corrosion and Loading Engineer, The Detroit Edison Co., Detroit, Mich.

## Topic of the Month

Corroded areas, bright copper color.



Hole entirely through sheath under bond wire.

Figure 1

ures within a year, at or adjacent to the bond connection or under the copper wire which held the cable designation tag in place, an investigation revealed the lead sheath to be corroded at the following representative locations:

1. Where the copper bond wire was making contact with the sheath at points other than where the sweated connection was made.
2. Under the wiping solder when the strands or sheath had not been properly tinned or interstices were left around the strands which allowed moisture to migrate under the wiping solder.
3. Under the copper wire which held the cable designation tag in place when the wire was in direct contact with the sheath.

The degree of corrosion at the above locations varied from none to holes in the lead sheath, with the amount of moisture present a deciding factor. Lead mon-

oxide was usually the product of corrosion. In a number of cases pieces of monoxide, up to half-inch in diameter, could be removed from the sheath with the aid of a shave hook. At some locations where the strands had not been tinned properly, it was found that the wire could be moved back and forth within the wiping solder or away from the sheath. This provided a serious condition under which fault current might readily have burned a hole in the sheath if an adjacent cable had failed.

An arc-proof wrapping of asbestos tape soaked in water-glass normally is installed over exposed cable sheaths to protect them against damage from external burns. Line designation tags also are installed at terminals by means of a copper wire twisted around the cable, over one of the layers of asbestos tape.

Figure 1 shows the corrosion damage resulting from an incorrect installation of the copper bond wire, allowing it to make contact with the lead sheath adjacent to its point of attachment to the sheath and under the (formerly-used) concrete, arc-proof coating. After a period of three years, sections of the 9/64-inch thick lead sheath were entirely disintegrated.

Corrosion damage resulting from an inadvertent installation of a copper tag wire is shown in Figure 2. The tag wire was installed in contact with the sheath, under the asbestos, arc-proof covering, and had been kept wet by sodium chloride drippings. A power fault resulted. An example of damage resulting from the incorrect attachment of a bond wire also is shown in this figure. This installation lasted less than six years.

Sixteen years ago, the following protective measures were inaugurated with gratifying results:

1. Use only clean, tinned wire for attachment as bonds to the cable sheath.
2. Bend bond wire at right angles to sheath before attaching, and completely cover contact area between copper and lead with wiping metal, insuring that metal penetrates between the strands. Allow no other contact between the bond wire and sheath.
3. Install tag wire under the outer layer of asbestos tape. This means that it is to be attached over the inner one or two layers, as the case may be.

Such precautions as the above may seem elementary to the corrosion engineer but, if care is taken to thoroughly acquaint the construction men with the consequences of careless workmanship considerable grief may be avoided.

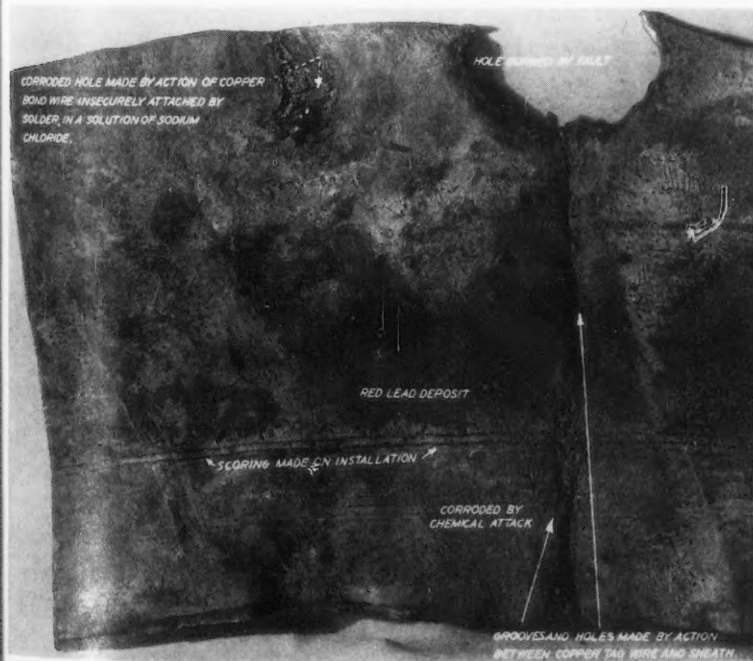


Figure 2





# NACE News

## Boston and Buffalo Sections Are Being Planned

### Two or Three More Corrosion Short Courses Are Proposed for '50 by Executive Group

Plans are being made to publish lessons and outlines of lectures given during the Corrosion Short Course at University of Texas, Austin, September 12-16. If published, copies of the lectures will be sent to those attending. Copies also will be available to others interested at a nominal cost while the supply lasts.

Prof. Norman Hackerman, of the University of Texas, who was in charge of arrangements for the Short Course on Corrosion held September 12-16 at Austin at the university under auspices of NACE has been named chairman of a committee to investigate the possibility of holding two or three short courses during 1950. This announcement was made by NACE President R. B. Mears during a meeting of the executive committee October 2, in Dallas, Texas, prior to the South Central Regional meeting. It has not been determined, Dr. Mears pointed out, whether a short course will be held again at Austin in 1950.

F. L. LaQue, immediate past president of the association urged that every effort be made to encourage the holding of a short course in the Metropolitan New York area during the coming year.

#### Letter from Holland

Dr. Mears read a letter from Delft, Holland from an NACE member there suggesting that some form of cooperative arrangement between Netherlands engineers interested in corrosion control and the NACE be effected as to the exchange of data and otherwise. Dr. Mears was authorized by the committee to propose several alternate means whereby this could be effected.

Dr. Mars G. Fontana, chairman of the NACE Technical Practices Committee has been asked to survey members of his committee for suggestions of types of investigation into corrosion-control matters by universities for fellowship studies. The procedure to be followed was tentatively defined as: 1. Publication of the collected list from TP members. 2. Accumulation of further suggestions from NACE membership. 3. Submission of the combined list to the technical practices committee for the preparation of a final list.

#### NACE Awards Selection

F. J. McElhatton, chairman of the 1950 NACE Awards Committee, charged with the selection of candidates to receive the Speller and Whitney Awards given annually by the association to two men considered to be best qualified in the fields of corrosion engineering and

science respectively, appeared before the committee and suggested that the selection be based principally on the results of a mail ballot of NACE membership.

#### Paint Association Representation

A. C. Goetz, Eagle-Picher Co., Cincinnati, Ohio and Kenneth Tator, consulting engineer, Coraopolis, Pa. were named to represent NACE on the National Paint, Varnish and Lacquer Association.

American Welding Society was announced as a new member of the Inter-Society Corrosion Committee, with G. W. Oxley, Standard Oil Development Co., Elizabeth, N. J. and M. A. Schiel, A. O. Smith Corp., Milwaukee, Wis. named as representatives. Both are NACE members. F. L. LaQue succeeds Dr. C. D. Hocker as representative of ASTM on this committee.

#### Abstract Publication

Negotiations are being conducted with the American Society for Metals regarding the possibility corrosion abstracts collected by NACE might be combined with those of ASM and published by ASM in its annual publication on metal abstracts. No decision has been reached on the proposal.

A nominating committee for national association officers to be seated at the end of the 1950 conference in St. Louis was named by Dr. Mears to report its recommendations at the January meeting of the board of directors. This action was taken under the old articles of organization because the procedures established under the new articles do not become effective until January 1.

Named on the committee were the regional directors, Vice-President Vance Jenkins and Past President F. L. LaQue.

Present for the executive committee meeting, in addition to Dr. Mears, Mr. Jenkins, Mr. LaQue, Mr. O. C. Mudd, treasurer, Mr. A. B. Campbell, executive secretary, Mr. L. A. Baldwin, were Mr. J. Pat Casey, Jr. The Crane Co., Chicago, Ill., general chairman of the 1950 Conference; Dr. Ivy Parker, editor of Corrosion and Norman E. Hamner, managing editor, Corrosion.

Metropolitan New York Section scheduled a talk by Kenneth Tator, Kenneth Tator Associates, Coraopolis, Pa., at its November 9 meeting at The Building Trades Employers' Association, 2 Park Ave., New York. Mr. Tator's scheduled topic was "Organic Coatings in the Chemical Industry."

Organization of sections of NACE in Boston and Buffalo, and a campaign publicizing the association among members of the Associate Committee on Corrosion Research and Prevention of the National Research Council of Canada were among the principal topics discussed at a meeting of North East Region members September 20 at 260 South Broad St., Philadelphia, Pa.

The region members, R. H. Lynch, T. P. May, H. L. Hamilton, G. E. Best (representing E. F. Wolf) and L. E. Donovan, also discussed the scheduled November region-section joint meeting with Baltimore Section.

Secretary-Treasurer L. B. Donovan said a list of names of approximately 129 members of the Associate Committee on Corrosion Research and Prevention of the National Research Council of Canada had been forwarded by Hugh P. Godard of Kingston, Ontario. This list, plus a proposed letter explaining the functions of NACE intended for distribution among those named, was forwarded to A. B. Campbell, executive secretary, suggesting that it be distributed from Central Office. Mr. May advised he would seek to find suitable persons to initiate a new section in the Boston area and would notify the secretary-treasurer of his findings. Development of a section in the Buffalo area also was discussed.

Growing work in connection with the development of added sections in the region brought the suggestion a paid secretary might be needed to handle region affairs, perhaps for two adjoining regions.

Dropping of the Corrosion magazine feature "Corrosion Problems," also brought the suggestion that Mr. Lynch discuss at the Dallas regional meeting the advisability of the magazine changing items of basic policy without consultation with regional officers.

A nominating committee to propose a slate of officers for the region for 1950 was named. The members, R. H. Lynch, Philadelphia, chairman and A. S. Brookes, Newark and R. H. Coe, Pittsburgh, are scheduled to present their nominations at the region-section meeting at Pittsburgh in October.

Baltimore Section scheduled a dinner meeting Tuesday, November 1 at Park Plaza Hotel beginning at 6:30 p.m. with I. A. Denison, of the National Bureau of Standards presenting a talk entitled "Effect of Properties of Soils on Corrosion of Materials of Construction Underground." The Transmission and Distribution Committee of Edison Electric Institute also scheduled a meeting in Baltimore Oct. 31-Nov. 1, and several members interested in Dr. Denison's topic were invited to attend.

Metropolitan New York Section heard C. P. Larrabee, of Carnegie-Illinois Steel Corp. research laboratory give an interesting talk Wednesday, September 28, on the corrosion of ferrous metals of various copper content in industrial and marine atmospheres.

Fifty-six were present to hear Mr.

Larrabee and to hear the introduction of new officers by E. P. Noppel, chairman of the NACE policy and planning committee. The dinner and lecture were held at Building Trades Employers' Association.

Pittsburgh Section and North East Region NACE scheduled a joint meeting in the Pittsburgh Room of the William Penn Hotel, Pittsburgh, October 20.

The meeting is scheduled on the day following the Water Conference of the Engineers Society of Western Pennsylvania.

Morning and afternoon technical sessions were announced, the tentative program including papers on: Aluminum in the Chemical Industry, Surface Treatment of Metals, Underground Corrosion and Corrosion by Waters.

A dinner also was scheduled following the technical sessions.

## Greater St. Louis Section's 8-Month Program Outlined

An 8-month program of meetings, including names of speakers and subjects has been arranged by Greater St. Louis Section. The section also plans to eliminate the office of corresponding secretary and divide the office of secretary-treasurer into the offices of secretary and treasurer.

The schedule released by Wm. F. Gross, corresponding secretary is as follows:

October 17—Speaker, F. L. LaQue, International Nickel Co., N. Y., "The NACE—Its Aims and Role in the Development of Experience in Combating Corrosion Problems."

November 21—Speaker, Dr. M. A. Scheil, Director, Metallurgical Research, A. O. Smith Corp., Milwaukee, Wis., "Effects of Carbon, Columbium and

Molybdenum on the 18-8 Austenitic Stainless Steels."

December 19—Speaker, L. G. Vande Bogart, Crane Co., Chicago, Ill., "Process Chemicals Corrosion."

January 16, 1950—Speaker, F. W. Davis, Chief Metallurgist, E. B. Badger & Sons, Boston, Mass., "Some Aspects of the Design and Fabrication of Equipment for Corrosive Service."

February 20—Speaker, O. C. Mudd, Senior Corrosion Engineer, Shell Pipe Line Corp., Houston, Texas, "Protective Coatings."

March 20—Speaker, R. H. Brown, Chief Chemical Metallurgy, Div., Aluminum Research Laboratory, Aluminum Company of America, New Kensington, Pa., "Possible Applications of Aluminum as Demonstrated by Corrosion Test Data."

April 20—Speaker, Dr. N. E. Berry, Servel Inc., Evansville, Ind., (Joint meeting—American Institute of Chemical Engineers, Engineer's Club and NACE) "Corrosion Engineering" (Title tentative).

May 15—Speaker, Dr. R. B. Mears, Director of Research, Carnegie-Illinois Steel Corp., Pittsburgh, Pa., "Causes of Localized Corrosion."

A business meeting of the section was held September 19 in the Gun Room at Edmonds Restaurant, St. Louis, Mo. There were 16 members and guests present and no speaker.

## NACE CALENDAR

**NORTH EAST REGION**—Board of trustees meeting scheduled November 18.

**METROPOLITAN NEW YORK SECTION**—Regular meeting November 9. Building Trades Employers' Ass'n., 2 Park Ave., New York, N. Y.

**PHILADELPHIA SECTION**—Next regular meeting Dec. 13. Election of Officers scheduled.

**SHREVEPORT SECTION**—Regular meeting day is second Thursday monthly.

**HOUSTON SECTION**—Meeting Dec. 13 will be devoted to a group discussion on "Application of Cathodic Protection."

**TULSA SECTION**—Meets second Monday monthly.

**WESTERN REGION**—Results of the election of officers will be announced at the next regular meeting November 30.

## MEETINGS

### November

7-10—API Annual Meeting, Stevens Hotel, Chicago, Ill.

### December

4-7—American Institute of Chemical Engineers, Pittsburgh, Pa.

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E-11

# Philadelphia Section Tours Lukens Steel Plant

## 65 NACE Members Guests During Coatesville Visit

About 65 members of the Philadelphia Section NACE made an inspection trip through the Coatesville, Pa., works of Lukens Steel Company during the afternoon of September 20, the regular meeting date. Of special interest to the corrosion engineers were the clad shops and the laboratories where samples of steels clad with a variety of generally corrosion-resistant materials are tested.

Small groups of the engineers were conducted through the plate mills, flanging department, flame cutting plant, sodium hydride surface cleaning shop, engineering and testing laboratories and welding shops. The engineers showed pronounced interest in the operations of this, one of the oldest steel plants in the country (housing a 206-inch plate mill, reputed to be the world's largest), which is engaged extensively in specialized fabrication.

Following the inspection section members were guests of Lukens Steel at a dinner at the Coatesville Country Club, following which there was much interested discussion with representatives of the steel company on various aspects of the works operations.

While no formal business meeting was held Chairman H. L. Hamilton announced the appointment of a nominating committee headed by Earnest Wyche to select a slate of officer candidates to be voted on at the next regular meeting, December 13, at a place to be announced. The officers elected then will take office January 1, 1950.



F. B. Foley, chief research engineer, The M'd-vale Co., Philadelphia and Thomas T. Watson, director of research, Lukens Steel Co., Coatesville, Pa.

### NACE MEMBERS

*IF You Change Addresses*

*IF You Change Company Affiliation*

*IF You Change Positions*

Please notify the Central Office NACE, 919 Milam Building, Houston 2, Texas, so that you will get CORROSION without delay and that association records can be kept abreast of your progress.

**THANKS!**



Examining specimen heads in the research department are (left to right): W. J. Powers, acting manager, Clad and Conversion Sales, Lukens Steel Co. (guide); H. L. Hamilton, corrosion engineer, Keystone Pipe Line Co., Philadelphia, Pa., chairman Philadelphia Section NACE; R. H. Lynch, vice-president, Keystone Pipe Line Co., North East Region Director NACE; H. F. McCoomy, chemical engineer, Atlantic Refining Co., Philadelphia and L. B. Donovan, Consolidated Edison Co. of New York, Inc., North East Region secretary-treasurer NACE.



In the research department (left to right): Henry Peters, Lukens Steel Co. (guide); G. E. Borst, manager, Philadelphia office, Chicago Bridge & Iron Co.; W. Aretz, salesmanager, W. A. Briggs Bitumen Co., Philadelphia; W. R. Briggs, president Briggs Bitumen Co.



Fred J. Myers, sales department, Lukenweld Div., Lukens Steel Co., (guide); R. L. Benedict, engineer, A. V. Smith Co., Philadelphia; E. R. English, sales department, H. C. Price Co., Philadelphia, secretary-treasurer Philadelphia Section NACE; A. V. Smith, consulting engineer, A. V. Smith Co., vice-chairman, Philadelphia Section; R. A. Ritchings, development engineer, Lukenweld Div.



## Statham Takes Post as South Central Chairman

South Central Region Officers for 1949-50 were elected at Dallas during the annual conference October 3-4. The new officers, who took office immediately, are: Tom R. Statham, Magnolia Pipe Line Co., Dallas, Texas, chairman; George A. Mills, Central Power & Light Co., Corpus Christi, Texas, vice chairman; M. C. Fleming, Phillips Petroleum Co., Bartlesville, Okla., secretary-treasurer; Harry E. Waldrup, Gulf Oil Corp., Houston, Texas, assistant secretary-treasurer.

T. F. P. Kelly, James E. Mavor Co., Houston, Texas, was named director, but will take office following the national conference in St. Louis during April, 1950.

Attendance at the two-day session was good, and high interest was shown in the corrosion panel discussion, which was attended by over 200, and at sessions devoted to technical papers. Registration was 239.

The 1950 regional conference is scheduled for Houston, at a date to be announced later and a committee was named to select a site for the 1951 meeting.

Of particular interest was the panel discussion led by L. F. Scherer, Texas Pipe Line Co., Houston, where many questions relating to corrosion of pipe lines and refineries were answered.

A Fellowship Hour and Buffet was enjoyed by the engineers and their guests Monday evening.

## Interim Report of TP-3 Committee is Completed

First Interim report of Technical Practices Committee TP-3—Anodes for Impressed Currents, has been approved for publication and is in process of preparation for printing. The report, which gives results of the committee's work on this subject so far, is a detailed summary of tests made over a period of one year. These tests are being continued for a total of four years. Objects are to determine the current carrying capacity and anode life of carbon, graphite, and steel pipe anodes under a wide variety of soil conditions and back-fill compositions.

Tables and curves of data obtained are included with summaries of results on four ground beds.

Ohio State University's department of metallurgy has received two two-year fellowships, each for \$1500 from The International Nickel Co., Inc., N. Y. and Titanium Alloy Manufacturing Division, National Lead Co., Niagara Falls, N. Y. William H. Santschi is recipient of the International Nickel fellowship and F. Lewis Orrell, Jr., recipient of the Titanium Alloy fellowship. Both are working for doctorates in metallurgy.

## Expanded Scope Outlined For TP-1 Group's Work

An expanded scope was adopted by Technical Practices Sub-Committee No. 1 (TP-1) at a meeting of the committee in Dallas, Texas, October 2, prior to the South Central Regional meeting. The name of the committee has been changed to "Corrosion of Oil and Gas Well Equipment."

The organization of the group will be changed to accommodate it to the new objectives. It was decided that a vice-chairman be elected by secret committee ballot from four nominees.

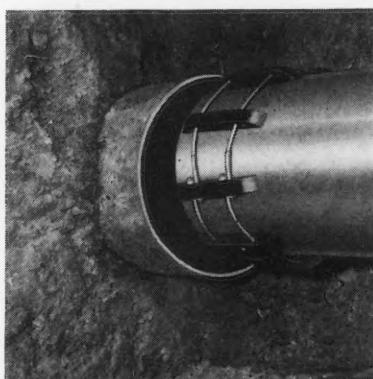
Future work of the committee will be

divided among four subdivisions of the group, whose chairmen are:

- A—Condensate Well Work. (Continuation of investigations) R. C. Buchan, Humble Oil & Refining Co., Houston, Texas.
- B—Galvanic Corrosion. Walter F. Rogers, Gulf Oil Corp., Houston, Texas.
- C—Sour Wells. H. D. Murray, The Texas Co., Midland, Texas.
- D—Sweet Wells. H. L. Bilhartz, Atlantic Refining Co., Dallas, Texas.

The sub-committee chairmen comprise a steering committee, the chairman of which is Ted Zajac, Shell Oil Co., Houston, chairman of TP-1.

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This device—simple, rugged, economical—supports and guides the leading end of coated line pipe into the right-of-way casing under railroads and highways.

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# 1949 Permian Basin Tour Is Attended by 162



Barbecue given during Permian Basin corrosion tour being enjoyed by Dr. W. J. Clayton, guest speaker; Dean Murray, section vice-chairman; Jack Hamilton, chairman exhibition committee; D. C. Glass, NACE director and Aaron Gensburg, section chairman.

**Corrosion  
News Deadline:**  
**10th of Month  
PRECEDING  
Date of Issue**



New fire tube with magnesium anodes attached prior to installation being inspected by Group 1-B during Permian Basin corrosion tour.



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Casing removed from well because of failure by corrosion after five years' sour crude service is being inspected by Group 2-C during Permian Basin corrosion tour.



Fire tube of heater-treater used in separating water from West Texas sour crude. Zinc anodes shown attached to inside of fire tube with rubber-covered hooks were ineffective.

The four-day annual Permian Basin Corrosion Inspection Tour, September 27-30, based on Midland, Texas and sponsored by the Permian Basin Section NACE was attended by 162 corrosion engineers. Installations inspected included crude oil storage tanks, well production equipment and coating processes. More than a dozen coatings were examined under a wide variety of conditions. Eighteen manufacturers exhibited products and services during the event, the first time an exhibit has been held in connection with the tour.

Three daily tours, each with three groups, were followed by evening discussions. Evening session chairmen were H. D. Murray, The Texas Co., Midland; W. H. Crenshaw, American Inspection Service, Midland; Roy Zuefeldt, The Texas Co., Jal, New Mexico.

Guest speakers for evening lectures were: F. L. LaQue, The International Nickel Co., Inc., N. Y., "How Coatings May Affect Corrosion;" O. C. Mudd, Shell Pipe Line Corp., Houston, "Resume of NACE Progress;" Dr. W. J. Clayton, Minnesota Mining & Mfg. Co., Detroit, Mich., "Effective Use of Vinyl Coatings in Control of Oil Field Corrosion."

Aaron Gensburg, chairman of the Permian Basin Section welcomed those attending following registration Monday morning. Jimmy McRae, A. J. Hunt Contracting Co., Midland, acted as master of ceremonies at a barbecue held Friday afternoon.

## Houston Section's 7-Month Schedule is Outlined

Tentative schedule of meetings and programs for seven months beginning with October has been published by Houston Section, NACE. The tentative schedule follows:

October 11—Two motion pictures and a round table discussion on "Corrosion-Erosion."

November 8—"Fundamentals of Cathodic Protection," by Lyle R. Sheppard, Shell Pipe Line Corp., Houston, Texas.

December 13—"Application of Cathodic Protection," group discussion.

January 10, 1950—"Corrosion Protection on Offshore Drilling Platforms," by E. D. Doremus, Cathodic Protection Service, Houston, Texas.

February 14—"Corrosion Inhibition by Film Formation." Speaker to be named.

March 14—"Condensate Well Corrosion Summary." Speaker to be named.

April 11—"Combating Corrosion in a Chemical Plant with Galvanic Anodes." Speaker to be named.

## Barcelona Meeting

The International Society of Industrial Chemistry, 28, Rue Saint-Dominique Paris (VIIIe), held its Twenty-second International Congress of Industrial Chemistry at Barcelona, Spain, October 23-30 inclusive.

## Films on Cavitation Are Houston Meeting Feature

Two motion pictures about cavitation were main features of the October 11 meeting of the Houston Section. The first film, produced for the U. S. Army by Gulf Oil Corp., was a slow-motion analysis of flow through an aircraft fuel pump. Varying conditions of altitude were simulated in an effort to determine the cause of pump failure. Viewed through a transparent cover, characteristics of the flow and causes of cavitation were seen readily. The second film was part of a test conducted by Phelps-Dodge Copper Products Corp., for the U. S. Navy. Cavitation effects and bubble formations on a "bullet" in a water tunnel were objects of this study.

High camera speeds were useful in slowing motion so formation and dissipation of bubbles along the surface could be observed.

Preceding the films, John E. Loeffler, of the Thornhill Craver Co., Houston, gave a discussion. He accompanied the films with a narrative and at the conclusion conducted a group discussion.

On display in the meeting room were samples of cavitation effects supplied by the Houston Lighting and Power Co., Diamond Alkali Co., Thornhill Craver Co., and Dow Chemical Co.

Following this portion of the program a film "Football Highlights of 1948" was shown through courtesy of Humble Oil Co., Houston.

Three well-known corrosion authorities were guests of the Houston Section September 22 at Central YMCA, Houston. They were F. L. LaQue, International Nickel Co., Inc., New York City; L. G. Vande Bogart, Crane Co., Chicago, Ill.; Col. George C. Cox, Consulting Engineer, Charleston, W. Va.

Mr. LaQue, immediate past-president of NACE, and recipient of the Speller Award, led an informal discussion by the group. Everyone attending was invited to submit questions about corrosion and the three guests made suggestions or recommendations in reply. Several inquiries and replies were illustrated by black board illustrations.

In addition to the informal session Mr. LaQue gave a brief illustrated talk about some of the experimental work of International Nickel.

Among 74 present were members of ACS, AIChE and ASM.

## Organization Meeting of Salt Lake Section Held

Twenty men representing the Geneva Steel Co., Kennecott Copper Co., Utah Oil Refining Co., Mountain States Telephone & Telegraph Co., Mountain Fuel Supply Co., The Bryan Patterson Co., University of Utah, and Utah Power & Light Co. met September 27 at Salt Lake City and decided to formally organize an NACE Section for the Salt Lake City area. An organization meeting is scheduled to be held during October.

Selected temporary chairman to preside until permanent officers are elected was Harry Brough of the Mountain Fuel Supply Co.

A list of addresses of new members and changes of addresses of old members will be a monthly feature of CORROSION magazine.

## Proposed Schedule Given For South East Region Annual Meeting Nov. 15

Proposed schedule for the November 15 South East Region meeting is as follows:

- 9:00 am to Noon—Registration.
- 10:00 am—Executive committee meeting.
- 1:00 pm—"Fundamental and Practical Aspects of Protective Coatings," by R. P. Devoluy, C. A. Woolsey Paint & Color Co., New York, N. Y.
- 2:00 pm—Discussion. R. P. Devoluy, leader.

3:00 pm—Recess.

3:15 pm—Business meeting.

3:45 pm—"Stray Current Electrolysis," by Bethel Bond, Wimer Engineering Co., Dallas, Texas.

4:15 pm—Discussion. Bethel Bond, leader.

6:30 pm—Dinner.

8:00 pm—"Use of Aluminum in Chemical Industry," by E. D. Verink, Aluminum Co. of America, New Kensington, Pa.

Section and region secretaries are urged to use forms provided by NACE for reporting meetings and attendance at meetings to Central Office and CORROSION magazine.



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**Western Region** will hold its next regular dinner meeting November 30, when results of the election of officers for 1950 will be published.

**San Francisco Bay Area Section** scheduled a dinner meeting October 11 at El Curtola Restaurant, Oakland, at which W. G. Collins, Pacific Telephone & Telegraph Co., was programmed to speak on "Corrosion of Lead-Sheathed Cable." This preceded a corrosion clinic on the program. The section began publishing notices of its meetings in the October issue of "The San Francisco Engineer" a publication devoted to schedules of professional associations of engineers.

## Revised Tentative Schedule of '50 Conference Technical Program Symposia Is Published

Following is the status of arrangements for the technical program to be presented at the 1950 NACE conference in St. Louis, Mo., April 4-7, together with persons responsible for preparation and presentation of material and the tentative time schedule:

**Tuesday P.M.—April 4**  
**CORROSION PRINCIPLES SYMPOSIUM**  
Dr. Norman Hackerman, University of Texas, Austin, chairman, and Dr.

H. H. Uhlig, Massachusetts Institute of Technology.

**Wednesday A.M.—April 5**  
**CHEMICAL INDUSTRY SYMPOSIUM**  
F. A. Rohrman, Engineering Experiment Station, University of Colorado, Boulder, Colo., chairman; W. Z. Friend, The International Nickel Co., Inc., 67 Wall Street, New York 5, N. Y. and F. L. Whitney, Jr., Monsanto Chemical Co., 1700 S. Second St., St. Louis 4, Mo., co-chairman.

**CATHODIC PROTECTION SYMPOSIUM**  
Robert J. Kuhn, 2724 Octavia St., New Orleans 15, La., chairman; Harold A. Robinson, The Dow Chemical Co., Midland, Mich. and Sidney E. Trouard, New Orleans Public Service, Inc., 317 Baronne St., New Orleans, La., co-chairmen.

**Wednesday P.M.—April 5**  
**TRANSPORTATION INDUSTRY SYMPOSIUM**  
Joseph Winlock, The Budd Co., Hunting Park Ave., Philadelphia 32, Pa., chairman; L. W. Smith, Cornell Aeronautical Laboratory, Inc., Buffalo, N. Y., co-chairman.

**OIL AND GAS INDUSTRY SYMPOSIUM**  
E. Q. Camp, Humble Oil & Refining Co., P. O. Box 538, Baytown, Texas, chairman; T. S. Zajac, Shell Oil Co., Inc., P. O. Box 2099, Houston 1, Texas and M. S. Northup, Standard Oil Development Corp., Elizabeth, N. J., co-chairmen.

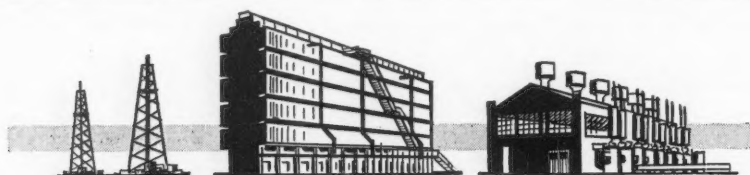
**Thursday A.M.—April 6**  
**PROTECTIVE COATINGS SYMPOSIUM**  
R. P. Devoluy, C. A. Woolsey Paint & Color Co., Inc., 229 East 42nd St., New York, N. Y., chairman; George Diehlman, National Lead Co., 105 York Street, Brooklyn, N. Y. and Kenneth Tator, Montour Street Extension, Coraopolis, Pa., co-chairmen.

**FRESH AND SALT WATER CORROSION SYMPOSIUM**  
L. M. Mosher Shipbuilding Division, Bethlehem Steel Corp., Quincy 69, Mass., chairman; J. A. Davenport, Corps of Engineers, P. O. Box 1159, Cincinnati 1, Ohio, and A. W. Tracy, The American Brass Co., P. O. Box 830, Waterbury 85, Conn.

**Thursday P.M.—April 6**  
**FOOD INDUSTRY SYMPOSIUM**  
C. E. Maier, Continental Can Co., 4645 W. Grand Ave., Chicago 39, Ill., chairman, H. A. Trebler, National Dairy Research Lab., Long Island, N. Y.

**PIPE LINE CORROSION SYMPOSIUM**  
R. A. Brannon, Humble Pipe Line Co., Drawer 2220, Houston 1, Texas, chairman; W. E. Huddleston, Huddleston Engineering Co., P. O. Box 998, Bartlesville, Okla. and S. S. Smith, Prod-

(Continued on Next Page)



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ucts Pipe Line Dept., Shell Oil Co., Inc., 50 West 50th St., New York 20, N. Y., co-chairmen.

Friday A.M.—April 7

#### PIPE LINE PROTECTION ROUND TABLE

F. J. McElhatton, Panhandle Eastern Pipe Line Co., 1221 Baltimore Ave., Kansas City 6, Mo., chairman.

#### GENERAL CORROSION PROBLEMS ROUND TABLE

F. L. LaQue, The International Nickel Co., Inc., 67 Wall Street, New York, N. Y., chairman.

### Preprints of Two Dallas Program Papers Available

Preprints of two of the technical papers presented at the October 3-4 South Central Region meeting in Dallas were made by Central Office for the account of the region. Copies remaining after sales made during the regional gathering will be offered for sale by Central Office as long as the supply lasts. They sell for 50c a copy. In order to save time and bookkeeping it is requested that those ordering endeavor to enclose payment in advance.

The preprints are:

"The Use of Ammonia in Control of Vapor Zone Corrosion of Storage Tanks," by F. T. Gardner and A. T. Clothier of The Carter Oil Co. Research Laboratory, Tulsa, Okla. and F. Coryell, Interstate Oil Pipe Line Co., Tulsa, Okla.

"Causes of Corrosion in Airplanes and Methods of Prevention," by N. H. Simpson, Chief Chemist, Consolidated Vultee Aircraft Corp., Fort Worth Div., Fort Worth, Texas.

### NACE Lapel Pins Are Ready for Delivery Now

Lapel pins for members of the National Association of Corrosion Engineers now are available for immediate delivery from Central Office, 919 Milam Building, Houston 2, Texas.

The gold pins, attractively designed in the shape of the official NACE emblem are inset with red and blue enamel with a ruby center. The price is \$7 each. Orders should be addressed to A. B. Campbell, Executive Secretary.

#### SELECTED BIBLIOGRAPHY ON SALT SPRAY TESTING

By Lorraine R. Voigt

Reprinted from Corrosion, 4, No. 10 (1948) Oct.

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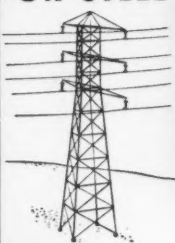
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## International Committee Is Formed on Electrochemical Thermodynamics, Kinetics

A new international organization, the "Committee of Electrochemical Thermodynamics and Kinetics" was organized at a meeting at University of Brussels, Belgium, March 28-30, 1949, among electrochemists from several Western European countries.

Goal of the committee is to facilitate and promote international cooperation in investigations of electrochemical thermodynamics and kinetics. Members of the committee are to be active research workers who will agree to orient some of their investigations in the directions which will be determined and occasionally revised at meetings of the committee. In each country where collaboration is secured there will be a delegate in charge of coordination of the various activities within the program of the committee.

Present officers of the group are Pierre Van Rysselberghe, University of Oregon, president; M. Pourbaix, University of Brussels, secretary. Delegates are A. Juliard, Brussels, for Belgium; F. E. W. Wetmore, Toronto, for Canada; J. Heyrovsky, Prague, for Czechoslovakia; G. Charlot, Paris, for France; T. P. Hoar, Cambridge, for Great Britain; R. Piontelli, Milan, for Italy; W. G. Burgers, Delft, for The Netherlands; A. B. Winterbottom, Trondheim, for Norway; E. Jimeno, Madrid, for Spain and E. Wyler, Bern for Switzerland.

The program of work outlined at the Brussels meeting was:

1. Preparation of an "Atlas of Electrochemical Equilibria," which will be an extension of the fundamental work of M. Pourbaix on the potential-pH diagrams of iron, copper, chromium, etc., to all elements for which the necessary data are available. This atlas is being prepared at present by M. Pourbaix, P. Delahay and P. Van Rysselberghe.
2. Systematic determination of polarization curves for electrochemical reactions. This vast program would consist of the extension of the fundamental work of Wagner and Traud, of the development of the polarographic method and of overvoltage studies, etc.
3. Applications of the two groups of investigations above to studies of corrosion, catalysis in solutions, electrolytic phenomena, analytical chemistry, etc.

Inquiries relative to the activities of this committee may be addressed to P. Van Rysselberghe, Department of Chemistry, University of Oregon, Eugene, Oregon.

National Bureau of Standards' 1948 annual report, a summary of investigations during the fiscal year, 272 pages, illustrated, is available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., 25 cents a copy.

United Gas Pipe Line Co. will start construction soon on a 15,000-square-foot laboratory at Shreveport, La. Estimated cost is \$325,000. Facilities for corrosion studies will be included.



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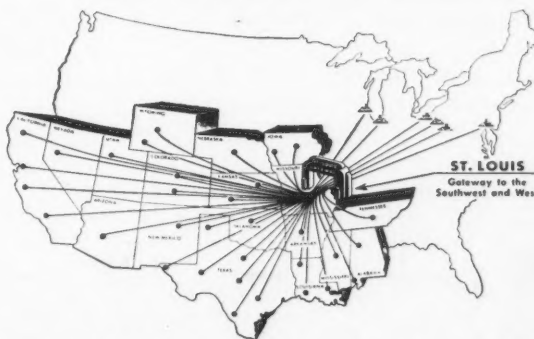
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## AICHe Pittsburgh Meeting Program Topics Are Given

Scheduled topics for the technical program of the 1949 annual meeting of the American Institute of Chemical Engineers to be held December 4-7 at Pittsburgh, Pa., include papers describing recent work in the fields of heat transfer, fluid flow and mass transfer, distillation and adsorption. Thermal data are to be presented for gases at high pressures, heat transfer media, fluidized systems, and fixed porous beds; correlations of heat transfer coefficients for various types of finned tubes.

Two papers describe velocity distribution and turbulent mixing in isothermal free jets. Fluid-solid systems also are to be discussed and physical separation problems covered.

## Electroplaters' Society Is Seeking Technical Papers

The 37th Annual Convention of the American Electroplaters' Society to be held June 11-15, 1950 at Hotel Statler, Boston, Mass., will include the Fourth International Electrodeposition Conference with the collaboration of the Electrodepositors' Technical Society of England.

Technical sessions planned include one on AES Research.

Papers for the technical sessions are being solicited. Authors desiring to submit papers are asked to advise the society's executive secretary at P. O. Box 168, Jenkintown, Pa. and request copies of the society's bulletins "Offer Form for Convention Papers, Regulations Governing Articles and Papers and Instructions to Authors."

Inquiries regarding reservations for the convention should be addressed to Manson Glover, 376 Washington St., Malden, Mass., or the society's headquarters at Jenkintown.

## AES Reports Offered

Complete sets of American Electroplaters' Society reports published to date now are being offered at a group price of \$5 as long as the supply lasts.

The fourteen reports are: No. 1, 2, 3—The Adhesion of Electrodeposits; No. 3 and 6—Determination of Impurities in Electroplating Solutions; No. 4 and 7—Stripping of Copper from Various Base Metals; No. 5 and 10—Porosity of Electrodeposited Metals; No. 9 and 14—Disposal of Plating Room Wastes; No. 11—Physical Properties of Electrodeposits; No. 13—Effect of Impurities and Purification of Electroplating Solutions. Inquiries should be addressed to AES, P. O. Box 168, Jenkintown, Pa.

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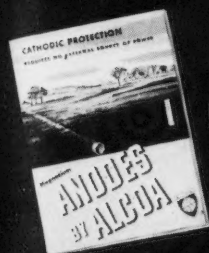
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# NEW PRODUCTS—Materials—Service—Literature

**Anti-Rust Protection** for parts machined with the use of an additive "501 Oilsaver" to water soluble cutting oils is claimed by The Beacon Rust-Proofing Mfg. Co., 20 East 33rd St., New York 16, N. Y. One part in 400, manufacturers claim, allows a 50 percent reduction in oil with no loss in cooling standards. Free test kits are available, if the request is accompanied by data respecting the nature of the cutting operation to be performed, and type of cutting oil used.

**Middle West Coating and Supply Co.** has been formed at Tulsa, Okla., by Maynard H. Jackson, a member of the NACE board of directors. Mr. Jackson, who resigned as sales manager for Standard Pipeprotection, Inc., to form the new firm, and who has been active for 19 years with companies in the corrosion-mitigation field, announces his firm will handle products used in the protection of metal surfaces including coal tar enamels, Koppers Cold Coatings, Oklahoma Glass Fiber reinforcement, pipe line felts and cathodic protection equipment, including rectifiers, flanges, fasteners.

**Air-Activated valves** for process control in sizes from 3 through 12 inches are being offered by Fischer & Porter Co., Hathero, Pa. The new line is described in Catalog 70, available on request.

**Magnesium Forms** constructed of 3-16-inch plate are being manufactured by the Symons Clamp and Manufacturing Co., Chicago, Ill. The forms' high rigidity and smooth surface, and their resistance to corrosion by alkalis in concrete are assets additional their light weight.

**Glass Fibers, Inc.**, Waterville, Ohio, has been awarded a 30 million square foot contract to supply pipe wrap for the Mid-Valley Pipe Line Company from Longview, Texas, to Lima, Ohio. Negotiations for the transaction were handled by M. J. Crose Manufacturing Co., Tulsa, distributor for "Vitron," the material introduced at the Cincinnati NACE conference.

**Rubber-Like Plastic** materials developed to give resistance to corrosive chemicals and mechanical damage, and already found to be particularly advantageous when used on pipes, tanks, drums and process equipment subject to strong corrosives are announced by United Chromium, Inc. Developed by the Organic Coatings Division of the company, they have been named Uni-chrome, Plastisol and Organosol Compounds. The development of the compounds follows more than two years of experience in producing plastisols for insulating electroplating racks. The materials are delivered in paste-like form.

The plastisols contain 100 percent solids while the organosols contain a small percentage of liquid solvent or diluent. They can be molded, dipped applied as spray or brush coatings from .003-inch to .25-inch with a single application. The cured compounds are said to resist acids, alkalis, salt solutions, oils, gasoline, greases, industrial oxidants and a number of other types of chemicals and products normally corrosive to rubber. Upon baking at about 350° F for 20 to 30 minutes, the materials set and take on a rubber-like appearance.

**"Flawmaster,"** a thermosetting compound used to reclaim metal parts and castings which would be rejected otherwise because of surface flaws, pitting, gas holes, faulty surfaces, has been developed by W. Jordan Nathason and Gordon W. Knapman, for Western Sealant, Inc., 9042 Culver Blvd., Culver City, Calif. The machinable material is said to be chemically inert.

**Angier VPI** wrap industrial applications of vapor phase inhibitor impregnated materials to prevent rust is outlined in a 24-page printed piece. The mailing piece consists of text and photographs showing how major industries use the VPI wrapping. VPI wrap is made by The Angier Corporation, Farmington, Mass.

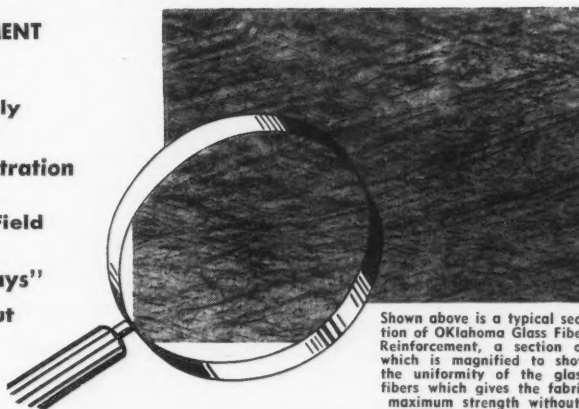
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## NEW PRODUCTS

**Hill, Hubbell & Co.**, a division of General Paint Corp., 2627 Army St., San Francisco, Cal., has issued the fifth edition of the "Book of Pipe Protection," describing pipe protection methods used by the company. The 22-page book is illustrated and contains complete information on coating and wrapping applications, grit cleaning, pre-heating, inspection methods, delivery scheduling, load unit shipping and field handling of pipe. The book is recommended as useful for engineers, technicians and purchasing executives.

**Formica Bushings** to insulate sections of pipe lines are being produced for reducing couplings in  $\frac{1}{4}$ ,  $\frac{3}{8}$ ,  $\frac{1}{2}$ ,  $1\frac{1}{4}$ ,  $1\frac{1}{2}$ , 2 and 3-inch sizes by The Formica Company, 4614 Spring Grove Ave., Cincinnati 32, Ohio. High mechanical and dielectric strength are claimed.

**Red Lead Technical Letter No. 4**, giving formulas for lead paints for Marine exposures can be obtained from Lead Industries Association, 420 Lexington Ave., New York 17, N. Y.

**Ucilon 1701**, a new general maintenance paint recently placed on the market by the Organic Coatings Division, United Chromium, Inc., is based on chlorinated rubber. The paint is designed for service where ordinary oil or oleo-

resinous paint is inadequate. It is said to be of value for resistance to acid and alkali fumes, moisture, vapors, grease and oils. It can be used on metals, wood, brick, concrete, over old paint or other surfaces without sandblasting or other surface treatments. Loose rust scale should be removed, however. One or two coats only usually are required. Complete information can be secured from United Chromium, Inc., 51 East 42nd St., New York 17, N. Y.

Taylor Spiral-Weld Pipe specifications and recommended uses are outlined in Bulletin 493 of Taylor Forge & Pipe Works, Inc., P. O. Box 485, Chicago, Ill. The bulletin is available on request.

## PERSONALS

**R. S. (Bob) Harris** has been added to Dowell, Inc., Houston district operating station to serve an expanding industrial market. Mr. Harris formerly was stationed at Beaumont as sales engineer and has been with Dowell in the New York, Philadelphia and Illinois industrial areas.

**Rolland H. Bradford**, a native of Missouri, who has attended Oklahoma

A. & M. and who holds a CE degree from University of Arizona is in charge of the new 209 South LaSalle Street, Chicago, Ill., office of Ebasco Services. Mr. Bradford has been with Ebasco for more than 20 years.

**Dr. Paul W. Bachman** has been named manager of the newly formed department of Development Planning by Davison Chemical Corp., Baltimore 3, Md. Dr. Bachman, with a background of experience in research and development with E. I. duPont de Nemours & Co., General Chemical Corp., The Victor Chemical Works and Commercial Solvents Corp., is an NACE board member.

**David C. Minton, Jr.**, assistant to the director of Batelle Institute, Columbus, Ohio, has been named executive in charge of sponsor relations and projects development.

**John L. Parsons**, president of Troy Engine & Machine Co., Troy, Pa. manufacturers of power equipment, announces formation of a Process Machinery Division with the purchase of two well-known lines as a nucleus.

**Dr. Louis Bryant Tuckerman**, member of the research staff of the National Bureau of Standards has retired. He is known for many contributions to the mechanics of materials and structures and was inventor of the Tuckerman optical strain gauge.

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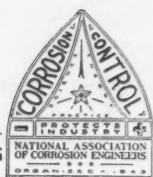
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# Corrosion Abstracts

## CHEMICAL

**Recent Advances in Zinc Hydrosulphite Bleaching of Groundwood.** R. R. FERGUSON. Paper before Spring Session of Western Branch, Tech. Sect. Canadian Pulp and Paper Ass'n, Ocean Falls, B. C., May 26-27, 1948. *Paper Trade J.*, 127, No. 16, 52-55 (1948) Oct. 14.

The system for handling of zinc hydrosulphite for bleaching of groundwood pulp has been modernized using stainless steel tanks and other corrosion-resisting materials. The groundwood system with the bleaching installations is shown diagrammatically.—INCO.

**Corrosion of Metals by Organic Liquids.** (In French.) R. DUBRISAY. *Mémoires & Corrosion*, 23, 278-284 (1948) Dec.

The corrosion of copper, aluminum, nickel, and tin by fatty acids in organic solvent solutions of chlorine solvents carbon tetrachloride, chloroform and methanol was studied. Data are tabulated and charted.—BLR.

**Brief Report of Symposium on Aspects of Packaging with Particular Reference to the Food Industry.** Society of Chemical Industry. *Chem. & Ind.*, No. 49, 778-779 (1948) Dec. 4.

Includes note on a paper, "Metal Containers," by R. K. Sanders, dealing with requirements, leakage problems, corrosion, etc.—BNF.

**New Chlorine-Caustic Plant for the Southwest.** *Chem. Inds.*, 63, No. 6, 956-959 (1948) Dec.

Description of Diamond Alkali's new plant for production of chlorine and caustic soda. For 73% caustic, part of 50% solution is evaporated in a vertical nickel tube high concentrator. Bodies and circulating liquor piping of double-effect evaporators are cast iron. Single bodies are Inconel-clad and piping is Inconel. All circulating pumps have either Inconel or Monel impellers and trim; double-effect pumps have cast iron casings and single pumps Ni-Resist cast iron casings.—INCO.

**Monosodium Glutamate.** *Chem. Eng.*, 55, No. 4, 136-139 (1948) Apr.

Corrosion difficulties encountered in the production of glutamic acid and its sodium salt has led to the use of stainless steel and rubber-lined equipment. An illustrated flowsheet of the process is included.—INCO.

**Equipment and Construction Materials for Seventeen Important Chemicals.** *Chem. Eng.*, 55, No. 11, 99-115 (1948).

The chemicals referred to are acetic acid, ammonia, cane sugar, chlorine and caustic, fatty acids, hydrofluoric acid, hydrogen peroxide, nitric acid, phenol, phosphoric acid (wet process and dry process), salt, soap, sulphate pulp, sulphite pulp, sulphuric acid, and whiskey.—MA.

## Abstract Section Style Outlined

For ease in locating reference data, CORROSION uses a uniform style in its Abstract Section.

The abstracts first are broken down into major classifications of the more common types of corrosion literature. In each review the title of the article is presented in bold face type, followed by the author's name. The publication from which the article was abstracted is printed in italics and is abbreviated in most instances. Following this, in sequence, are the volume (bold face), number in the volume, pages, year and month of publication. In some instances a second reference will be listed in the same manner. This indicates that the article also was published or abstracted in another publication. A brief summary of the article follows the above information and it is concluded with an abbreviation indicating the source of the abstract and contributor. The meanings of these abbreviations usually are listed on the first page of the Abstract Section.

When seeking more detailed data about an abstract, best source of information is the publication in which the article appeared originally. (Listed in italics in the heading.) The contributor of the abstract also may be able to supply additional information. Addresses of most of these publications may be found in the reference section of most public libraries.

## COATINGS

**The Pre-treatment of Metals (Before Organic Finishing).** *Product Finishing (Lond.)*, 1, No. 5, 50-55 (1948).

A very general survey of the available methods for the pre-treatment of a wide variety of metals prior to organic finishing. These are summarized in a useful table.—MA.

**Finishing Aluminium Alloy Die-Castings.** *Product Finishing (Lond.)*, 1, No. 5, 65-66 (1948).

A mat or frosted finish is produced on silicon-containing aluminium alloys by immersion in a 4% caustic soda solution at 60° C., followed by rinsing and a nitric-hydrofluoric acid dip. After a further rinse, the treatment is completed by a final dil. nitric acid dip, rinsing and drying. Where silicon-free aluminium is to be treated, the hydrofluoric acid is omitted from the first acid solution.—MA.

**Automatic Production in the Treatment of Metallic Surfaces.** G. MYOT, *L'Usine Nouvelle (France)*, 1948, 21 (1948) Sept.

Several special machines for increasing production in the treatment of metallic surfaces, built by la Ste. Maurice Demien are: Machines for polishing caseroles and pots, installations for copper or nickel plating, and installations for the anodic oxidation of aluminium. Installations for polishing and chemical brightening of aluminium without the use of electricity are to be built. *Aluminium Information (France)* 3, No. 43, 14 (1948) Oct. 21.—ALL.

**Scale-Removal Time Reduced in World's Largest Salt Bath.** *Modern Machine Shop*, 20, No. 11, 198-199 (1948).

A description of a molten sodium hydroxide-hydride 800 kw. electrode-type salt bath for descaling clad plate, stainless steel, nickel, and Monel metal.—MA.

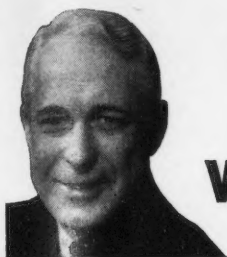
**Finishing Washer Tubs and Machines.** R. A. MOORE, The Sherwin-Williams Company, *Prod. Fin.*, 13, No. 3, 54-56 (1948) Dec.

The substitution of aluminum for steel in washing machine tubs created the

Abbreviations at the end of abstracts indicate source of abstract and contributor; and are as follows:

AER	Aeronautical Review, Institute of Aeronautical Sciences, Inc.
ALL	The Abstract Bulletin, Aluminum Laboratories, Ltd.
AWWA	Journal, American Water Works Association
BLR	Battelle Library Review, Battelle Memorial Institute Library
BNF	Bulletin; British Non-Ferrous Research Association
CALCO	Calco Chemical Division, American Cyanamid Corp.
CE	Chemical Engineering, McGraw Hill Publishing Co.
CEC	Consolidated Edison Co. of New York, Inc.
EW	Electrical World, McGraw Hill Publishing Co.
GPC	General Petroleum Corp. of California
INCO	The International Nickel Co., Inc.
IP	Institute of Petroleum
MA	Metallurgical Abstracts, Institute of Metals, London, Eng.
ME	Marine Engineering
MR	Metals Review, American Society of Metals
NALCO	National Aluminate Corp.
NBS	National Bureau of Standards
RA	Refrigeration Abstracts, American Society of Refrigeration Engineers
RM	Revue de Metallurgie, Paris, France
RPI	Review of Current Literature Relating to the Paint, Colour, Varnish & Allied Industries, Research Association of British Paint, Colour & Varnish Manufacturers, London.
TDD	Technical Data Digest, Air Materiel Command—Technical Service Section
UOP	Universal Oil Products
No Code	Current Technical Literature, Bell Telephone Laboratories

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problem of securing an organic finish which would withstand the effects of the alkali and abrasion encountered on the interior of washer tubs. This problem has been solved in one case by the adoption of a new finish known as Superclad. This entails a six-stage pre-paint setup as follows: 1) Parker 101 and 301 water conditioner; 2) hot water rinse; 3) Bonderite No. 34; 4) Bonderite No. 170; 5) cold water rinse; 6) chrome acid rinse. The primer and enamel are applied by spray gun. Following the application of the enamel the washers are monobaked 26 minutes in a gas-fired convection oven. Satisfactory results also have been obtained over anodized and alodized aluminum.—ALL.

**Aluminum-Coated Steel Strip.** *Metall.*, No. 5-6, 83-84 (1947).

The production of steel strip coated on each side with a layer of pure aluminum 0.01-0.3 mm. thick is described. Such material can be used for telephone membranes, many kinds of cans, flexible metal tubes, and domestic and cooking equipment.—MA.

**Protective Coatings.** JOSEPH MAZIA. *Machine Design*, 21, 110-114 (1949) Jan.

Describes characteristics and applications of chemical-conversion finishes of various types for application to metals.—BLR.

**Light Alloy Piston Materials.** A. SCHOFIELD AND L. M. WYATT. *Metallurgia*, 37, No. 220, 187-194 (1948) Feb.

This is a very exhaustive article on light alloy piston materials. Typical compositions are tabulated, and a special table shows relationship between alloy names (English) and basically similar

alloys. Designations of aluminum-copper-nickel-magnesium cast forged alloys are included. Nickel is used for its hardening effect, persistent at high temperatures. Total percentage of iron-manganese-nickel is limited by considerations of castability and ductility. Manganese is kept as low as possible, in order to accommodate more nickel. If strength and castability are outstanding properties desired, copper, magnesium, and silicon predominate with iron and nickel added up to total of 2% with grain refiner. For low coefficient of expansion, alloy has a high silicon with sufficient copper, nickel and magnesium for hardness needed. Susceptibility of the various alloys to hot tears, coarse and fine shrinkage, fine and coarse structure is tabulated and discussed. Heat treatment, service temperature conditions, mechanical, physical, thermal and bearing properties are discussed and graphed. Aluminum-silicon types show better wear resistance than aluminum-copper-nickel-magnesium types. Under extremely bad conditions of lubrication and abrasion it has been found that service equal to that obtainable with a cast iron piston, with only a small sacrifice in weight, may be achieved by using a "ring carrier" insert of austenitic cast iron. Insert is placed in mould prior to casting and the differential contraction holds it firmly. London bus piston is shown after 90,000 miles service.—INCO.

**The Microstructure of Low-Carbon Steel.** R. L. RICKETT AND F. C. KRISTUFEK, U. S. Steel Corp. Paper before ASM Ann. Conv. Philadelphia, Oct. 25-29, 1948. Trans. ASM, Preprint No. 4, 29 pp. (1948).

Many photomicrographs of rimmed steel containing 0.06% carbon and 0.43% manganese are given to show 1) isothermal transformation of austenite, 2) precipitation of carbide from ferrite as influenced by prior structure, 3) amount of cold reduction, and 4) effect of annealing variables after heating near or below the aluminum equilibrium temperature. Ferrite forms very rapidly from austenite even above 1335° F, the  $A_{e1}$  temperature; transformation of the remaining austenite requires a very long time at 1300° F and a very short time at 1000° F and the resulting microstructure depends upon temperature of transformation and the extent of carbon enrichment of the austenite, due to rejection of ferrite, prior to its transformation. Appreciable hardening may result from the retention of carbon in solution in ferrite by rapid cooling, with further hardening at room temperature. Much of the carbon may be precipitated by slow cooling or by reheating after quenching. Size and distribution of carbides depend upon the temperature at which they are formed. Microstructure after commercial low-temperature annealing near or below  $A_{e1}$  is influenced by prior ferrite grain size, carbon distribution, amount of cold reduction, annealing time and temperature and sometimes by rate of cooling.—INCO.

**The Production of Lithium Metal.** R. R. ROGERS AND G. E. VIENS, the Canadian Mining and Metallurgical Bulletin (Canada), No. 439, 623-628 (1948) Nov.

With the increasing importance of lithium in the metallurgical field, and with the presence of deposits of lithium—containing minerals in Canada, investigations are being carried out to determine the various reactions of lithium, its compounds and alloys. A recent sample of spodumene ore from Cat Lake, Manitoba, was found, after concentration, to

contain 4.46% lithium oxide ( $Li_2O$ ), which is equivalent to approximately 2% lithium metal. It also contained 66.20% silica, 22.00% alumina, and smaller amounts of other constituents, including lime and magnesia. Electrolytic production of lithium alloys is discussed, with detailed procedure of the production of lithium-copper-aluminum alloy given. A table shows lithium content and some properties of alloys produced. The lithium alloys can be handled more cheaply than pure lithium. The procedure for the production of pure lithium from alloys by distillation at low pressure is given, the copper-aluminum-lithium alloy procedure and results being described in detail. Results of corrosion tests, listed in tabulated form, indicate the resistance of lithium alloys. It is believed that certain lithium alloys of zinc and aluminum will be superior to the corresponding commercially pure metals as regards corrosion resistance.—ALL.

## CONSTRUCTION MATERIAL

**Aluminum Exploration Equipment Has Advantages in Gulf Coast Marshes.** L. S. MCCASLIN, JR. *Oil and Gas J.*, 47, 88-89 (1948) Oct. 14.

Exploration equipment ranging from portable shot-hole drills to gravity-meter station platforms now is being made of aluminum for use in the inland marine areas of the Gulf Coast. Light weight and corrosion resistance are important factors. Use of magnesium is being considered.—ALL.

**Experiences With a Gold-Platinum Alloy as a Material for Laboratory Instruments.** (In German.) K. W. FROHLICH. *Angewandte Chemie*, Sec. B, 20, 72 (1948) Mar.

Compares gold-platinum alloy with pure platinum with respect to properties important in the laboratory. Results are summarized in tabular form, with respect to resistance to attack by various chemical reagents at elevated temperatures.—BLR.

**Directory of Materials.** *Chem. Eng.*, 55, No. 11, 116-28 (1948) Nov.

A poll of manufacturers of corrosion-resistant materials of construction is presented in tabular form, giving the name, manufacturer, description, and most important applications of all metals, carbonaceous materials, cements, ceramics, rubber products and plastics available to the corrosion engineer.

**"Constant-Flow" Pump for Highly Corrosive Liquids.** (In German.) E. W. BECKER AND E. HOLZ. *Angewandte Chemie*, Sec. B, 19, 254-255 (1947) Sept.

Describes and diagrams a special pump which operates at a rate of only a few 10 cc per hour. It can also be used to produce a vacuum.—BLR.

**Industrial Alcohol Versus Construction Materials.** *Chem. Eng.*, 55, No. 9, 247-248, Sept., No. 10, 235+ (1948) Oct.

In a symposium in which a representative group of construction materials are evaluated for services involving industrial alcohol, papers cover:

**Introduction** by W. C. Moore (U. S. Industrial Chemicals, Inc.), Chemical

## PRE-PRINTS

"CAUSES OF CORROSION IN AIRPLANES AND METHODS OF PREVENTION," By N. H. Simpson, Chief Chemist, Consolidated Vultee Aircraft Corp., Fort Worth Division, Fort Worth, Texas.

"CONTROL OF VAPOR ZONE CORROSION IN STORAGE TANKS BY THE USE OF AMMONIA," By F. T. Gardner and A. T. Clothier, The Carter Oil Co., and Francis Coryell, Interstate Oil Pipe Line Co., Tulsa, Okla.

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Lead by K. H. Roll (Lead Industries Association).

Iron & Steel by A. W. Spitz (American Cyanamid Co.).

Coatings: Nickel, nickel alloys by W. Z. Friend (INCO); tantalum by L. R. Scribner (Fansteel Metallurgical Corp.).—INCO.

**Hydrochloric Acid Versus Construction Materials.** *Chem. Eng.*, **55**, 231-232+ (1948) Dec., 231-232+ (1949) Jan.

Part I of a symposium in which a representative group of construction materials is evaluated for services involving hydrochloric acid. Includes the following: "Stainless Steel," W. G. Renshaw; "Lead," Kempton H. Roll; "Rubber Lining," O. S. Ture; and "High-Silicon Iron," Walter A. Luce. Part II of a symposium. Includes the following: "Carbon and Graphite," W. M. Gaylord; "Tantalum," Leonard R. Scribner; "Chlorimet," Walter A. Luce; "Iron and Steel," A. W. Spitz; and "Worthite," W. E. Pratt.—BLR.

**The Flax Wet Spinning Frame as a Source of Catalytic Damage in Bleaching.** W. HONEYMAN. Paper before Chem. Soc. & Royal Inst. of Chem., Joint Mtg., Belfast, Jan. 19, 1949. *Chem. & Inds.*, **91**, No. 6, 81-96 (1949) Feb. 5.

Discussion of the causes of catalytic damages in bleaching of linen cloth which were traced to electrolytically corroded particles of copper.—INCO.

**Corrosion Tests of a Heated Wing Utilizing an Exhaust-Gas-Air Mixture for Ice Prevention.** GEORGE M. HOLDAWAY. National Advisory Committee for Aeronautics, Technical Note No. 1791, Jan., 1949, 39 pages.

Contains results of an investigation of the extent of corrosive attack in an aluminum alloy wing. Includes tables of data and photographic illustrations.—BLR.

**Aluminum and Fruit Juices.** P. E. GILROY AND F. A. CHAMPION. *J. of the Soc. of Chem. Ind.*, **67**, 407-410 (1948) Nov.

The interaction of fruit juices and aluminum was investigated. It was found that pure aluminum and aluminum-manganese and aluminum-magnesium alloys are suitable for the storage of certain fruit juices. They are also suitable for citrus juices if the sulfur dioxide preservative is suitably controlled.—BLR.

**Solution of Carbon Steel by Monobasic Acids of the Aliphatic Series.** (In Russian.) V. D. YAKHONTOV. *Zhurnal Prikladnoi Khimii* (Journal of Applied Chemistry), **21**, 667-675 (1948) June.

The above was investigated. Results for the individual acids of the above series are tabulated, charted, and discussed.—BLR.

**The Acid Question—Hydrochloric and Sulfuric.** *Wire Ind.*, **16**, 60 (1949) Jan.

Discusses relative merits of the two acids as wire pickling agents.—BLR.

**The Effects of Additions to Pickling Acids.** K. WICKERT. *Arch. Metallkunde*, **2**, No. 2, 56-62 (1948).

The theory of the pickling process is described, together with the effects of additions, namely inhibitors, accelerators, and retarding agents. Measurements of the solution rate of metals and metallic oxides in pure acids at known concentrations and temperature, and in similar acids containing known amounts of addition agents, enable a quantitative estimation to be made of the value of such additions. It is shown that if Lx and Ly are the solution rates in acids with and without addition agents respectively, the following definitions apply: 1) Inhibitor, this greatly decreases the solution rate of the metal, but does not reduce, or only slightly reduces, that of the oxide, i.e.  $Lx \text{ (metal)} \ll Ly \text{ (metal)}$ , and  $Lx \text{ (oxide)} \leq Ly \text{ (oxide)}$ . 2) Accelerator, this greatly increases the solution rate of the oxide while only slightly increasing that of the metal, i.e.  $Lx \text{ (metal)} \geq Ly \text{ (metal)}$ , and  $Lx \text{ (oxide)} \gg Ly \text{ (oxide)}$ . 3) Retarder, this depresses the solution rates of both metal and oxide, i.e.  $Lx \text{ (metal)} \ll Ly \text{ (metal)}$  and  $Lx \text{ (oxide)} \ll Ly \text{ (oxide)}$ . The recognition of retarding agents, which have a negative pickling effect, is important in practice, as it is necessary to remove them from pickling solutions.—MA.

**Corrosion Gets the Cold Shoulder.** *Steelways*, No. 16, 18-19 (1948) May.

Stainless steel wire for food trays in refrigerators is used because of its resistance to corrosion and food acids. The wire is electrolytically polished and the application of electronic controls to welding machines, giving split-second control over pressure and time cycles, enable the manufacturers to solve the welding problem. How big the wires should be and how many should be in any one shelf is determined by the amount of bend or deflection allowed by refrigeration engineers. Because of its high tensile strength, stainless steel wire can be much thinner and still be as strong as other metals.—INCO.

**Corrosion Resistance Tests of Concrete Floors—With and Without Metallic Aggregate.** E. W. SCRIPTURE, JR., and C. H. SAKRYD. *J. Am. Concrete Inst.*, **20**, (Proc., **45**), part 2, 317-323 (1948) Dec.

What are the corrosion effects of phenol, molasses, lard, milk, and other agents? Based on tests of sample floor specimens the authors make recommendations for use of concrete floors subject to chemical attack.

**Automatic Chemical Process Control.** H. M. SCHMITT, Brown Instrument Co. Paper before Conf. on Instruments and Measurements, Stockholm, 1947. Trans. Conf. on Instruments and Measurements, **1948**, 150-159.

Discussion of various processes and methods of control includes corrosive conditions in control problems. Cast tubes, drilled tubes, and welded tubes of nickel, chromium, and iron alloys are mentioned as being used for thermo-couple protecting tubes.—INCO.

**The Study of Metal Corrosion by Fuels.** (In French.) P. SCHLAPFER and A. BUKOWIECKI. *Metaux & Corrosion*, **23**, 267-277 (1948) Dec.

The corrosive action of modern fuel components such as hydrocarbons, alcohols, aldehydes, ketones, and esters on iron, aluminum, zinc, lead, copper, and

magnesium alloys were investigated. Data obtained are tabulated. Method of investigation is described.—BLR.

**The Corrosion of Steel in Saline Solutions of Hydrogen Sulfide.** F. B. RYAN and R. A. SNOW. Thesis (BS) MIT (1948) 67 pp.

Hydrogen sulfide was found to be definitely anodic in its stimulation on the corrosion of steel. Total corrosion was increased by hydrogen sulfide although the intensity of corrosion decreases and becomes more uniform than when corroding under the influence of oxygen alone.

**Galvanic Action Between Lead, Worthite and Other Acid-Resistant Alloys in Sulfuric Acid.** W. E. PRATT and E. T. COLLINSWORTH, JR. *Corrosion*, **5**, 39-44 (1949) Feb.

Reports results of some preliminary investigations to determine the exact mechanism involved in the changes of the relative potentials of lead and some stainless steels, notably Worthite, in sulfuric acid. The work was done in order to shed light on corrosion of chemical pumps in which Worthite is anodic to large areas of lead. The trouble can be avoided by use of an oxidizing agent such as sodium chromite, ferric sulfate, or copper sulfate; by reaeration; or by insulation to prevent contact of the two metals.—BLR.

**Influence of Tellurium on Hydrogen Absorption of Steel During Its Cathodic Polarization in Solution of Sulfuric Acid.** (In Russian.) M. N. POLUKAROV. *Zhurnal Prikladnoi Khimii* (Journal of Applied Chemistry), **21**, 611-619 (1948) June.

Experimental data on the influence of tellurium on the above rate of hydrogen absorption are tabulated and discussed. 12 ref.—BLR.

**Action of Organic Acids on Stainless Steel.** CHARLES F. POE and E. M. VAN VLEET. *Ind. and Eng. Chem.*, **41**, 208-210 (1949) Jan.

Strips of stainless resist the action of most dilute organic acids at 25° C. and at boiling temperatures, with the exception of boiling oxalic acid in normal concentration. Data are tabulated.—BLR.

**Corrosion of Iron in Commercial Sulfuric Acids and Nitrosylsulfuric Acid Solutions.** (In German.) FRANZ OERTEL. *Angewandte Chemie*, ser. B, **20**, 125-128 (1948) May-June.

Presents results of systematic experiments made to determine the effect of temperature, density, and nitrosylsulfuric acid content on the resistance of different types of iron to corrosion with the object of replacing the lead linings of sulfuric acid vessels by iron. Data are graphed and tabulated. 16 ref.—BLR.

**Five Ways That Diesels Wear: Mechanical Action; Scuffing or Welding; Surface Disintegration; Abrasive Action; Corrosive Action.** *SAE J.*, **57**, 39-44 (1949) Feb.; discussion, p. 41. Excerpts from "Piston Ring and Cylinder Wear in Diesel Engines," by John W. Pennington.

Discusses the above processes. Effects of various factors are shown graphically. Discussion includes several suggested methods for combating wear. Emphasis is on chromium plating, neutralization of fuel sulfur, and improved surface finishing.—BLR.

**An Electrolytic Tank for Exploring Potential Field Distributions.** R. MAKAR.



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A. R. BOOTHROYD & E. C. CHERRY. *Nature*, 161, No. 4100, 845-846 (1948) May 29.

Two difficulties were experienced in exploration of potential distributions in electrolytic tanks, when alternating current is used: non-linear conduction due to polarization at the electrode surfaces, which becomes serious at very low potential differences or currents; and corrosion of the electrodes causing the conducting path to assume a leading power factor, which increases with increasing current density. Both effects are reduced by raising the working frequency, but are incompatible with one another if very fine probe electrodes are used. In a series of studies using solutions of copper sulfate in distilled water and copper electrodes, very accurate results were obtained with a measuring frequency of 1000 c/s and electrodes 0.5 mm diameter, provided that the current per electrode is not less than 5 MA or the current density does not exceed 0.3 MA/sq. mm. For such fine electrodes, steel sewing needles which were previously plated by the copper cyanide process, being rigid, are suitable. Attention was given to removal of errors due to the finite tank boundary, which can limit the usable fraction of the electrolyte surface.—INCO.

Enamel for Aluminum. RICHARD W. PORTER. *Chem. Eng.*, 55, No. 7, 170, 172 (1948).

Refers briefly to a synthetic heat-hardening enamel, suitable for outdoor exposure.—MA.

High Temperature Ceramic Coatings for Molybdenum. NACA Tech. Note 1626. *N. B. S. Tech. News Bull.*, 32, No. 11, 125-126 (1948) Nov.

Discussion of development of ceramic coatings for metals with very high melting points to protect them against oxidation at high operating temperatures. Ceramic coatings are applied in form of water suspensions to cleaned molybdenum by either dipping or spraying. After drying, the pieces are fired at 2150° F in oxygen-free atmospheres. One of the better coatings consisted of a base coat of low expansion frit with 20 zirconia added, a cover coat containing 95 zirconia, and a seal coat consisting of a thin application of same composition as base coat. Performance tests include heating in gas-oxygen flame, heating at constant temperature in an air atmosphere and service testing in blast of ram-jet engines. Oxidation of molybdenum was retarded by best of ceramic coatings tried. There was no decrease in thickness for ceramic-coated molybdenum heated for 70 hours in air atmosphere at 1650° F as there was for unprotected molybdenum sheet within one-half hour. At surface temperature of 2600° F, oxidation rate in gas-oxygen flame was retarded enough to make coated molybdenum feasible for high temperature applications where prolonged service is not required. One application is protection of molybdenum Pitot tubes built into nozzle end of ram-jet engines used for pilotless aircraft. Other applications include coated thermocouples and resistance thermometers made of high melting point metals.—INCO.

Collected Standard Specifications for (Water) Service Line Materials: American Water Works Association Committee Report. *J. Amer. Water Works Assoc.*, 40, No. 8, 883-889 (1948)—MA.

## FUNDAMENTALS

Use of an Electron Diffraction Camera as an Ultraoscilloscope, and Suggested Application to Contact Erosion. J. J. LANDER. *J. of Applied Physics*, 19, No. 12, 1128 (1948) Dec.

A high speed oscilloscope, obtained by adaptation of an electron diffraction camera, is described. A voltage sensitivity of about ten-trace widths per volt was obtained. The inductance and capacity measured as the terminals of the deflecting plates were 0.03  $\mu$ H and 4  $\mu$ F. The calculated time resolution was 0.0006  $\mu$  sec. Transients occurring in mechanical contact were studied, and experiment with gold and platinum contacts showed that

the "short arc" will accompany contact separation if the maximum voltage of the transient can reach a value of about 10 volts and a current larger than the minimum current necessary to support the arc can flow. Under such conditions the positive contact is eroded due to the fact that most of the inductive energy dissipated in a "short arc" is spent by boiling metal out of the contact.—ALL.

Investigations of Gas-Metal Reactions by Reflection Electron Diffraction. J. W. HICKMAN. Pittsburgh Internat. Conf. on Surface Reactions (Proceedings), 142-156 (1948); *NBS Sci. Paper*, No. 1362.

The merits and limitations of the electron-diffraction method of studying gas-metal reactions are considered. The following types of problem are discussed,

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and illustrated by experimental results: 1) structural changes or changes in crystal size during oxidation at constant temperature, 2) decomposition of one oxide to produce another oxide and oxygen, 3) reversible and irreversible transitions occurring when oxide-filmed metals are heated and cooled, 4) irreversible changes occurring when oxide films on binary alloys are heated in vacuo, 5) change in crystal size as the temperature is increased at constant film thickness, 6) changes in oxide-film orientation caused by substrate effects or growth effects, 7) existence regions of oxides occurring on metals or alloys as functions of time and temperature of oxidation, and 8) the relative tendencies of metals in binary alloys of cobalt, molybdenum, nickel, tungsten, and chromium to reach the surface and form oxides.—MA.

**Oxide Films Formed on Metals and Binary Alloys. An Electron Diffraction Study.** J. W. HICKMAN. *Metals Tech.*, 15, TP 2483, 18 pages (1948) Dec.

Results of study of films formed on a series of pure metals are summarized; the literature is reviewed and data on 31 binary alloys (titanium-nickel, titanium-copper, zirconium-copper, zirconium-cobalt, zirconium-nickel, molybdenum-tungsten, molybdenum-nickel, molybdenum-cobalt, molybdenum-chromium, tungsten-tungsten-nickel, tungsten-chromium, tungsten-copper, silicon-iron, chromium-iron, nickel-chromium, beryllium-copper, and copper-nickel, of various percentage ratios) are presented. Results are summarized, including the conclusion that it is impossible to predict the oxide that will be formed on the basis of thermodynamic stabilities or ion sizes. An empirical table in graphical form shows sums of relative rates of formation and diffusion of the several ions based on the data. 27 ref.—BLR.

**Lubrication and Lubricants—Additives in Lubricating Greases.** G. KAUFMAN. *Lubr. Eng.* 3, 55-61 (1947) May-June. *Gen. Elec. R.*, 50, No. 11, 58 (1947) Nov.

Some of the properties which may be improved by the use of additives in greases are: load-carrying ability; greater resistance to oxidation, heat, water and corrosion; better consistency, and improvement in rust prevention.—INCO.

**Microbial Decomposition of Resinous Stabilizing Agents in Soil.** P. C. T. JONES. *Chem. & Ind.*, No. 13, 201 (1948) March 27.

A report on work done to isolate, identify and inhibit organisms in soil causing decomposition of natural resins (as used in road-making). Mercuric chloride and sodium pentachlorophenate were found effective in inhibiting growth of organisms found (a proactinomyces, pseudomonads and other eubacteria and fungi, especially *Aspergillus nidulans*), and it is suggested that these organisms are markedly aerobic, that a compound inducing anaerobic conditions mixed with a persistent, stable antiseptic would give ideal results in preventing or delaying breakdown of waterproofing resins.—RCLPI.

**Production of Extremely Thin Metal Films by Evaporation on to Liquid Surfaces.** N. HAST. *Nature*, 162, No. 4127, 892 (1948) Dec. 4.

In a new method recently devised for making thin metal films a small amount of beryllium or aluminum was evaporated in a vacuum on to a liquid surface. It is specified that the liquid had to have a high boiling point and low vapor pressure

at room temperature. Glycerol was the chief liquid used, and each step of the procedure used in making metal films on the surface of this liquid is outlined. One of the greatest advantages of the new method compared with the old (small amounts of beryllium or aluminum was evaporated on the surface of a film of cellulose nitrate, etc., *Nature*, (1947) Mar. 15,) is that in the making of metal films for electron microscopical use it is possible to lay a metal film directly on an organic substance without using amyl acetate or other liquids which affect organic substances. The author gives a brief report on evaporating metals on to vacuum oil surfaces, and aluminum metal in a vacuum on to a mercury surface. In the case of the latter, the normal reaction which results when mercury and aluminum are put into contact with each other did not take place when the action occurred in a vacuum.—ALL.

**Electron Diffraction Studies on the Nature of the Corrosion Resistance of Stainless Steel. On the Ferrous Nickel Chromate Formed on the Surface of Stainless Steel.** SHIGETO YAMAGUCHI, TADAYUKI NAKAYAMA, AND TOMINOSUKE KATSURAI. *J. of the Electrochem. Soc.*, 95, 21-24 (1949) Jan.

Electron-diffraction measurements were made of surface films produced on 18%-chromium, 4%-nickel and 19%-chromium, 9%-nickel stainless steels. The films were formed by exposing the metals to water vapor at elevated temperatures and pressures in an autoclave. Comparison with X-ray diffraction data indicate that the film may be a solid solution of (nickel, iron)  $\text{CrO}_4$ .—BLR.

**Structure of Crystals of  $\gamma\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$  Formed During Corrosion of Iron.** (In Russian.) N. A. SHISHAKOV. *Zhurnal Fizicheskoi Khimii* (Journal of Physical Chemistry), 22, 953-955 (1948) Aug.

Results of X-ray diffraction study of the above are tabulated and discussed.—BLR.

**Research on the Mechanism of the "Pickling Brittleness" of Steel. III. The Influence of Preliminary Annealing of Armco Iron in Hydrogen on the Subsequent Diffusion of This Gas Into the Metal at Low Temperatures.** (In French.) PAUL BASTAIN. *R. de Metallurgie*, 45, 301-311 (1948) Sept.

Gives results of a preliminary investigation of the above problem. Data obtained clearly indicate the importance of hydrogen concentration in the gas layer adsorbed by iron and its release which causes brittleness. Experiments showed that the brittleness of the pickled monocrystals is not caused by absence of intercrystalline grain boundaries but by modification of the chemical activity of the metal itself, particularly of its surface.—BLR.

**A Theoretical Discussion of Pitting Failures in Gears.** R. BEECHING AND W. NICHOLLS. *Inst. of Mech. Eng., Proc.*, 158, 317-323; discussion, 323-326 (1948) Dec.

Primarily concerned with theoretical consideration of the stresses that cause surface failure of gear teeth. Methods of calculating permissible line load between contacting cylindrical surfaces for static or cyclic conditions are considered, and probable effects of friction are discussed. Maximum case thicknesses are suggested for steel components of varying core strength when subjected to contact stresses. Appendix describes derivation of expres-

sions for the principal stresses at any point in the neighborhood of the zone of contact between parallel cylinders.—BLR.

**Erosion Due to Incipient Cavitation.** W. T. BOTTOMLEY. *Inst. of Mech. Eng., Proc.*, 158, 297-307; discussion, 308-316 (1948) Dec.

Gives results of experiments which indicate that the bubbles which form and collapse at the stage of incipient cavitation in aerated water are air bubbles in a supersaturated state and that vapor bubbles which collapse in de-aerated water are in thermal equilibrium. It is shown that the collapse of bubbles in thermal equilibrium cannot cause erosion because the vapor pressure inside and the hydrostatic pressure surrounding the bubbles are balanced during collapse. The energy producing cavitation erosion is the free surface energy liberated by the collapse of the air bubbles. Effect of these views on interpretation of tests in cavitation tunnels and on cavitation number are discussed. Seventeen references.—BLR.

**Diffusion of Radioactive Copper During Oxidation of Copper Foil.** GILBERT W. CASTELLAN AND WALTER J. MOORE. *J. of Chem. Phys.*, 17, 41-43 (1949) Jan.

Strips of copper foil were plated with radioactive copper and oxidized in air at 800, 900 and 1000° C. From the distribution of radioactive copper in the oxide, diffusion coefficients for cuprous ion in cuprous oxide were calculated. These measurements provide further evidence that diffusion of  $\text{Cu}^+$  in  $\text{Cu}_2\text{O}$  is the rate-determining step.—BLR.

**Electronographic Investigation of the Size of Iron Crystals and the Thickness of Oxide Films Formed on Their Surfaces.** (In Russian.) P. D. DANKOV AND N. A. SHISHAKOV. *Z. Fiz. Khim.* (J. of Phys. Chem.), 22, 956-960 (1948) Aug.

The above was investigated by X-ray and electron microscopy. Data indicate that the film is composed at least of two elementary nuclei of gamma  $\text{Fe}_2\text{O}_3$ , and it is possible that one of them is  $\text{Fe}_3\text{O}_4$  and the other  $\text{Fe}_2\text{O}_3$ . The range of thickness is about 16-18 Å.—BLR.

## GENERAL

**Periodic Chemical Reactions.** (In German.) I. K. F. BONHOEFFER. II. The Cathodic Polarization of Iron in Nitric Acid. K. F. BONHOEFFER, ELFRIDE BRAUER, AND GUNTER LANGHAMMER. III. The Refractory State of Newly Passivated Iron in Concentrated Nitric Acid. K. F. BONHOEFFER, VERA HAASE, AND GUNTER LANGHAMMER. IV. Theory of the Cathodic Polarization of Iron in Nitric Acid. K. F. BONHOEFFER AND G. LANGHAMMER. *Zeitschrift für Elektrochemie und Angewandte Physikalische Chemie*, 52, 60-72 (1948) Mar.

Part I describes conditions necessary for periodic reactions to occur; also tells why, in heterogeneous systems, preliminary conditions are especially favorable to periodic reactions. Part II presents results of experiments on the topic indicated. Includes tables, graphs, and diagrams. In Part III the behavior of a passive iron wire in concentrated nitric acid which had been previously cathodically activated in this acid is described. In Part IV a theory concerning the chemical reactions on iron is developed. Data are tabulated and graphed. Thirty-seven references.—BLR.

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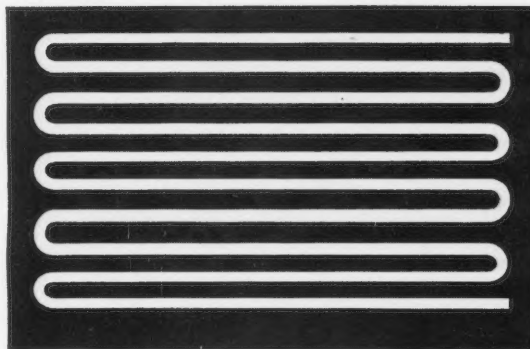
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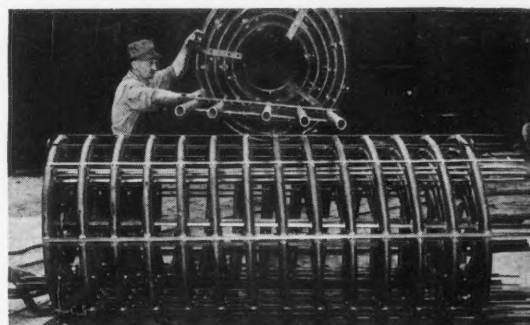
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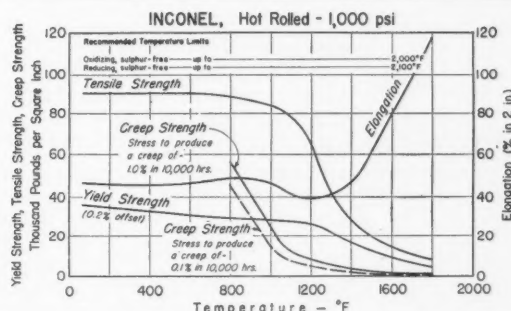
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#### HIGH TEMPERATURE PROPERTIES OF INCONEL

Additional information, such as stress-to-rupture chart, is available upon request.



**Galvanic Corrosion and Its Practical Significance.** G. T. COLEGATE. *Metal Treatment and Drop Forging*, 15, 183-192 (1948-9) Winter.

The fundamentals of corrosion are discussed. Conclusions are applied to practical conditions with special reference to copper, aluminum, iron, and magnesium alloys. Methods of corrosion prevention are reviewed. Fifteen references.—BLR.

**Theoretical Structural Metallurgy.** A. H. COTTRELL. Demy 8vo. Pp. viii+256, with 96 illustrations. London (1948). Edward Arnold and Co. (21s. net.)

Dr. Cottrell's book covers a very wide range, beginning with a general consideration of atomic structure and interatomic forces, and then proceeds to a review of the crystal structure and electron theory of metals and alloys. This is followed by chapters on equilibrium and the approach to equilibrium, including some thermodynamics from the viewpoints of entropy and free energy, which are then used to interpret the forms of equilibrium diagrams. The concluding chapters deal with diffusion, order-disorder changes, and phase precipitation by nucleation and growth.—MA.

**Metals Handbook. 1948 Edition.** Prepared under the direction of the Metals Handbook Committee. Edited by Taylor Lyman. 4to. Pp. xii+1444, with numerous illustrations. 1948. Cleveland (3), O.: The American Society for Metals, 7301 Euclid Avenue. (\$15.00.)

This new edition of the Metals Handbook is, on all counts, an impressive volume. It contains 40% more matter than the previous (1939) edition, and more than two-thirds of the articles which have been retained have been rewritten.

The "Handbook" began in 1924 as a collection of loose-leaf data sheets.

It is divided into four main sections—General, Ferrous Metals, Non-Ferrous Metals and Constitution of Alloys—and of these the last two are outstandingly the best. The section on non-ferrous metals has been completely overhauled and rearranged; and the new section on constitution contains the first comprehensive annotated collection of alloy phase diagrams to appear in the English language since 1927 (in the International Critical Tables). The diagrams alone will justify the cost of the volume to many readers.

The non-ferrous section is in ten parts. The first contains articles on general matters such as hot working, slush casting, and poisoning hazards, and the remaining nine deal respectively with aluminum, copper, lead, magnesium, nickel, tin, zinc, precious metals, and miscellaneous metals—and their alloys. The treatment of "copper and copper alloys," which extends over 102 pages, is typical of that given to each group. First there are ten general articles dealing with the casting, working, fabrication, corrosion-resistance, and applications of copper and its alloys. A useful monograph on the polishing and etching of these materials for metallographic examination is included here. These articles extend over about 60 pages; the remaining 40 are filled with data on pure copper, tough-pitch copper, phosphorus-deoxidized copper, 39 wrought copper alloys, and 25 copper casting alloys, set out in a conveniently-followed, concise, standard arrangement. The scheme provides for the inclusion of trade names, official specifications, uses, physical and mechanical characteristics, melting and deoxidation practice, working properties, and jointing procedure. In some in-

stances, extensive tables are given on such matters as corrosion-resistance, and free use is made of graphs. These "data sheets," like all articles in the handbook, appear as signed contributions (except when prepared by special sub-committees), and, being authoritative and up to date, are certain to be widely quoted.

The new, final, section on constitution of alloys contains 284 "phase diagrams," each accompanied by a short commentary and a list of selected references. Usually, each diagram has been prepared by an American authority on the system, and although experimental points are not plotted and the explanatory matter is very brief, a most instructive impression of recent advances in the knowledge of alloy systems is obtained by comparing the diagrams with those in any earlier collection. It may be noted that, with one small modification, the diagrams of the copper-zinc, copper-tin, aluminum-zinc, aluminum-copper, aluminum-magnesium, and lead-tin systems prepared by Dr. Raynor for the Institute's Annotated Equilibrium Diagram Series have been adopted. In addition to binary systems, a number of ternary systems are discussed and more or less complete diagrams reproduced for 28 of them.

The sections on non-ferrous metals and constitution are so excellent that it may be thought ungenerous to criticize the first general section. It is evident, however, that in revision this has not received the careful attention lavished on the later parts of the volume. Many of the articles contain too much padding and too few facts; and some of the authors need reminding that their contributions are for a work of reference and not for an elementary introduction to general metallurgy. The definitions, in particular, are

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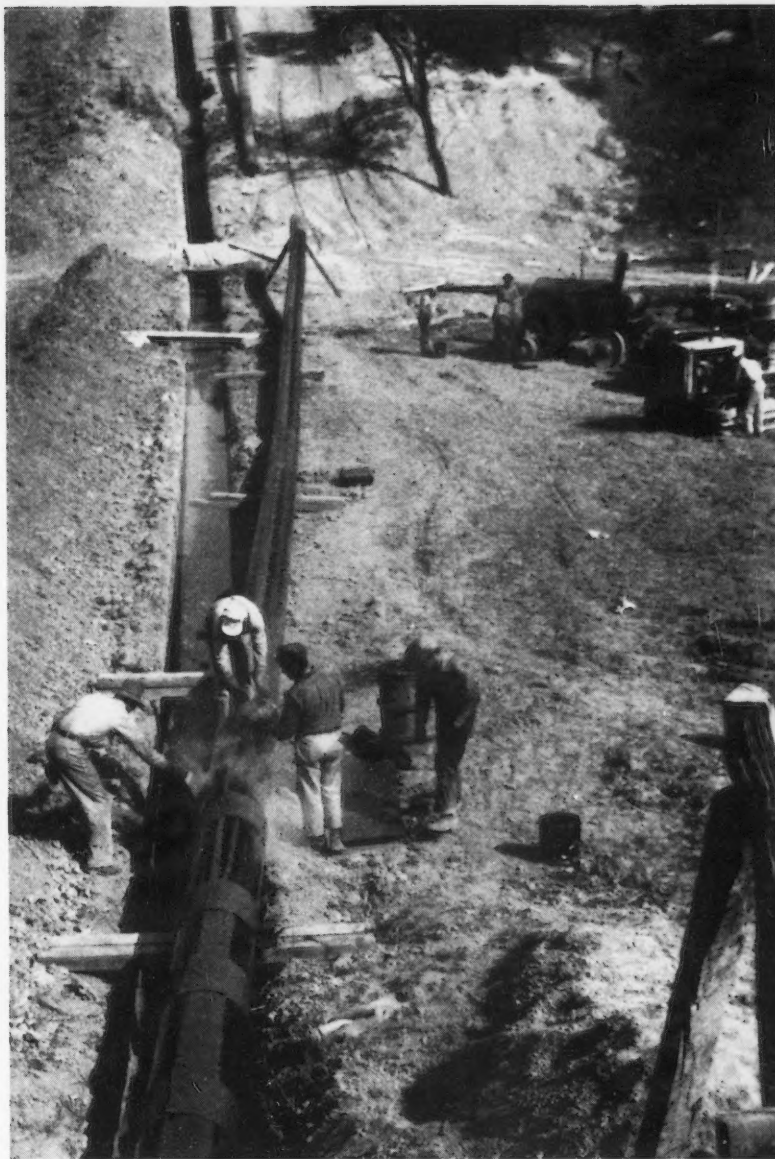
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in need of revision (even "eutectic alloy" is not rigorously defined); and there is, most surprisingly, a complete lack of data on such important matters as the solubility of gases in liquid and solid metals and rates of diffusion in metals and alloys. Furthermore, it has not been realized that there is an increasing need by physical metallurgists for more and more thermodynamic data and for reliable data on refractories and slag systems.—MA.

**FIAT Review of German Science, 1939-1946: General Metallurgy.** By MAX HANSEN ET AL. 22 x 15 cm. Pp. (viii) + 295. 1948. London: Board of Trade (German Division), Technical Information and Documents Unit, 40 Cadogan Square, S.W.1. (Limited circulation.)

Every page is crammed full of important information. Only a few pages may

be of interest to the specialist in a restricted field, but the whole volume is essential to those whose duties necessitate ranging widely over the field of metallurgy.

To judge from this Review, Germany has made a considerable contribution to the theory and practice of metallurgy during the war. It is impossible adequately to summarize the scope of the book, which ranges from the electron theory of metals to mechanical testing; a brief description must suffice. The format follows a now familiar pattern; the book is divided into eight main sections, all written in German, in several of which three or more authors collaborate, the whole being supervised by the senior author, Max Hansen. Each section has a formidable list of references, totaling more than 1400. There is also a bibliog-

raphy of some 70 books on certain aspects of general metallurgy recently published in Germany.

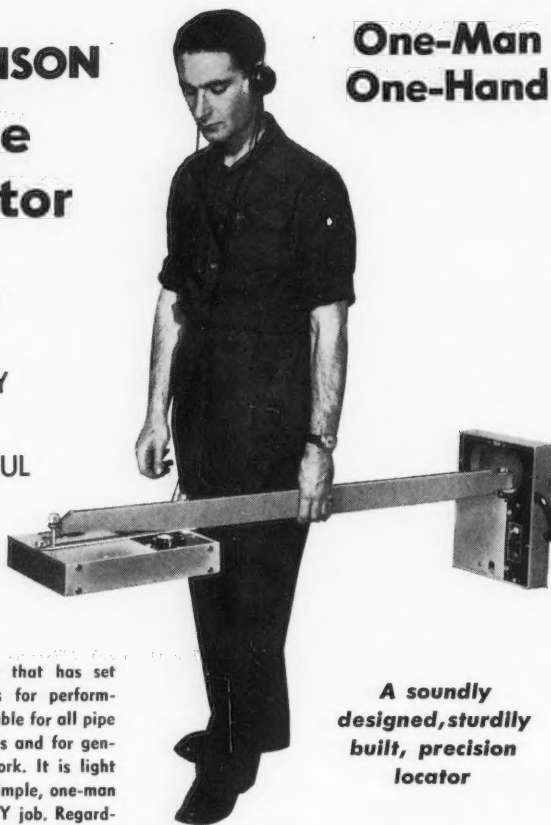
The review begins with an article by U. Dehlinger and H. Nowotny on the structure of metals and alloys (40 pp., 168 references). Dehlinger writes on the problem of cohesive forces in metals and alloys, while Nowotny's contribution takes the form of a discussion and classification of the crystal structures of intermediate phases in metallic systems. W. Köster contributes a short article on the elastic properties of metals, and the influence thereon of temperature, composition, and metallurgical changes (8 pp., 26 references). O. Kubaschewski, E. Gebhardt, R. Vogel, Th. Heumann, and A. Schrader collaborate to produce a long article concerned with the constitution of alloys, dealt with mainly from the experimental viewpoint (54 pp., 250 references). This includes sections on the thermo-chemistry of alloys, with some recent results, and a review of constitutional work carried out in recent years. Very brief abstracts are provided for some 150 binary systems, and references to ternary and quaternary systems are given. E. Scheil, O. Kubaschewski, and W. Hoffmann collaborate on changes of state (22 pp., 80 references) and discuss the nature of the liquid state and the crystallization of metals, diffusion in metals, and transformation in the solid state. Plastic deformation and recrystallization are treated by A. Köchendorfer (22 pp., 35 references). Microscopic, electronmicroscopic, and X-ray techniques for the examination of metals form the subject of the article by A. Schrader, H. Mahl, W. Hoffmann, and H. Neerfeld (22 pp., 132 references). The next article, on mechanical testing (E. Siebel, N. Ludwig, H. Nowotny, O. Vaupel, and H. Schallbroch (82 pp., 582 references) is perhaps the most exhaustive and informative in the whole book, and ranges from conventional tensile testing to the examination of surfaces. A chapter on corrosion (R. Ergang, G. Masing, G. Wassermann, and W. Wiederholt, 27 pp., 169 references), which includes reviews of both theoretical and practical aspects, and of research on stress-corrosion, completes the work.

As with previous volumes in this series, the outstanding feature is the invaluable list of references, many of which may be new. The style in which the various sections are written is variable, and some articles are very full accounts while others are little more than catalogues. Taken as a whole, however, the book is an authoritative account of what has been done in Germany in recent years, and as such is indispensable. It is therefore a matter for disappointment and real concern that the present edition should be so strictly limited, and that so few copies should be available. There should be copies for immediate consultation in every metallurgical library and research establishment if full advantage is to be taken of the co-operation of these German authors, and of the welcome efforts of the Field Information Agencies Technical to inform international science of German research. It is true that arrangements eventually are to be made for a more liberal reprinting, but it is doubtful whether this can be done in time to prevent the book from becoming a document mainly of historical, rather than of scientific importance.—MA.

**FIAT Review of German Science, 1939-1946: Physics of Solids, Part II.** By GEORG JOOS ET AL. 22 x 15 cm. Pp. (iv) + 235. 1948. London: Board of Trade (German Division) Technical Informa-

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This extremely useful review of work carried out in Germany during the war years deals with various subjects in pure physics. Almost all the book is of direct or indirect interest to those working on the theory of metals, though the more technical metallurgist may well find it of little assistance to him. The criticism leveled against Part I of this review that many of the articles tended to be mere catalogues of references, is again deserved, but does not apply as strongly to Part II. The references are still there, and form an invaluable part of the report, but the articles themselves (all written in German) provide more interesting information.

There are three main sections, each containing several articles, dealing respectively with the electrical, magnetic, and optical properties of solids. W. Klemm and E. Vogt deal with the magnetism of non-ferromagnetic materials (26 pp., 76 references). Methods of measurement and theory are discussed briefly, and recent work on normal paramagnetic properties, chiefly of inorganic compounds, is reviewed. Anti-ferromagnetism is considered, and its relationship to the nature of the binding and the crystal structure in the solid is stressed. Recent work on the magnetic properties of the elements, particularly the rare earths, is reported, and a short section on alloys is included. Magnetic data for alloys can be used to determine the valency state of the component atoms; thus the paramagnetic palladium dissolves in copper as a non-ionized diamagnetic atom; several other examples are discussed, including confirmation of the trivalency of aluminum in copper. New work on ferromagnetism is discussed from theoretical and experimental points of view by R. Becker (16 pp., 23 references). The article on the dielectric properties of solids (C. Schmelzer, 10 pp., 29 references) deals chiefly with amorphous and ceramic materials, while that on piezo-electric phenomena is also "non-metallic," but of interest. A good general article by J. Meixner (12 pp., 35 references) reviews the recent German work on galvanomagnetic, thermomagnetic, and thermo-electric effects in metals and semi-conductors, and considers the electron theory of the phenomena. New experimental work on supraconductors, and developments of the general theory of supraconductivity are discussed by W. Meissner and G. U. Schubert (20 pp., 31 references), and the section on electrical properties is completed with three articles by W. von Meyeren on electrical conduction and photo-electric conductivity in insulators, semi-conductors, and semi-conductor rectifiers, and with an article by G. Hettner on metallic conduction. These articles total some 70 pp. and contain 136 references. From this, it will be appreciated that much ground is covered, and it would appear that little of importance that happened in Germany has been omitted. In the section on the optical properties of solids, one article (G. Joos, 22 pp., 57 references) is chiefly concerned with non-metallic materials, while the other (W. Haule and A. Schmillen, 25 pp., 58 references) discusses the phosphorescence and luminescence of metallic oxides. There are, however, brief references to the optical properties of aluminum and of thin films of platinum and rhodium.

This work, and the previously published Part I, somewhat dispel the illusion entertained by some that fundamental phys-

ics in Germany languished during the war. It does not appear that anything startlingly new has been uncovered, but advances made in many fields are adequately reported. There is a good index, and the list of references is invaluable. These reviews merit careful study so that the work described may be integrated with that done in other countries over the same period.—MA.

## INHIBITORS

**Effect of Oxygen Concentration on Corrosion of Steel in Solutions Containing Metaphosphate Inhibitor.** R. V. Scott. Thesis (M.S.) M.I.T. (1948) 98 pp.

The action of a metaphosphate inhibitor (Calgon) in solutions containing varying amounts of dissolved oxygen (5-30 cc./liter) on the control and mitigation of corrosion was studied. The work was to determine whether or not Calgon would aid in bringing about passivity of iron corroding in a solution containing a high dissolved oxygen concentration. The corrosion rate of commercial black iron pipe was measured, using the oxygen-drop method, in untreated distilled water, distilled water treated with Calgon and tap water treated with Calgon. The results show that Calgon gave very good protection at all oxygen concentrations studied. The presence of Calgon did not increase the partial passivating effect observed in the case of both treated and untreated distilled water. When using treated tap water, the corrosion rate increased linearly with increasing oxygen concentration. The protective film formed by the Calgon built up rapidly in solutions containing a large amount of calcium and very slowly in solutions which contained a very small amount of calcium. Chloride ions had a destructive effect on passivation and on protective films. Copper ions interfered with the action of the Calgon.

## REFINERY

**Corrosion in Oil Tanks in England.** *Nat. Petro. News*, 40, No. 32, 25 (1948) Aug. 11.

Corrosion in oil tanks in England, as a consequence of moisture held against the tanks by the brick or tile encasement, constructed for protection against bombing, is necessitating a program for research on more favorable protection against future bombing possibilities.

**Some Particular Aspects Presented by Corrosion in the Petroleum Industry and Its Consequences in Relation to Remedies.** P. LACOMBE. Paper Assoc. Franc. des Techniciens du Pétrole, Feb. 24, 1948; *Bull. Assoc. Franc. Techniciens Pétrole*, No. 70, 2-18 (1948) Apr. 1.

A general review of corrosion problems in the petroleum industry discusses the preponderant role played by impurities of petroleum in corrosion, the use of minute amounts of substances to inhibit corrosion, and progress with metal alloys resistant to the corrosive effect of oxides and sulfides in hot gases. It is pointed out that a drop of water (as found in oil-water emulsions) is much more corrosive than a continuous film. The homeopathic effect, observed on addition to copper alloys of substances which will be attacked by the corrosive elements, while

the copper which has reacted is re-deposited on the metal, is exemplified by the dezincification of brass. A formula commonly used for metal condenser alloys is copper 70%, zinc 28.95%, tin 1% and arsenic .05%. This type of corrosion is very dependent upon the pH of the system, necessitating different alloys for alkaline or acidic mixtures. The homeopathic effect is also utilized for combating the corrosive effect of hot gases containing sulfides and oxides, by the addition of aluminum and silicon. The use of cathodic inhibition in sulfuric acid systems also is discussed.

**Pennsylvania Grade Crude Oil Association Joins Quarter-Century Ranks.** A. L. FOSTER. *Oil Gas J.*, 47, No. 7, 48-50 (1948) June 17.

Among the projects studied is search for corrosion inhibitors for use with low pH water.—INCO.

**Refining Saudi Arabia Crudes.** G. E. LOFF. *Universal Oil Products Co. Oil Gas J.*, 47, No. 35, 159-161+ (1948) Dec. 30.

Chemical neutralization of acidic constituents is limited to ammonia injection into fractionating tower. 18-8 chromium-nickel impellers are used on quench and polymer tower bottom pumps, while cast iron alloy impellers are used on all other pumps. Screens of clay tower are 18-8 tubes in heaters and chromium-molybdenum transfer lines protect selective cracking units. 12% chromium steel sheet lines reaction and flash chambers and fractionating tower, and constitute the bottom three-fourths of trays. 12% chromium alloy lines heavy oil and residuum pumps.—INCO.

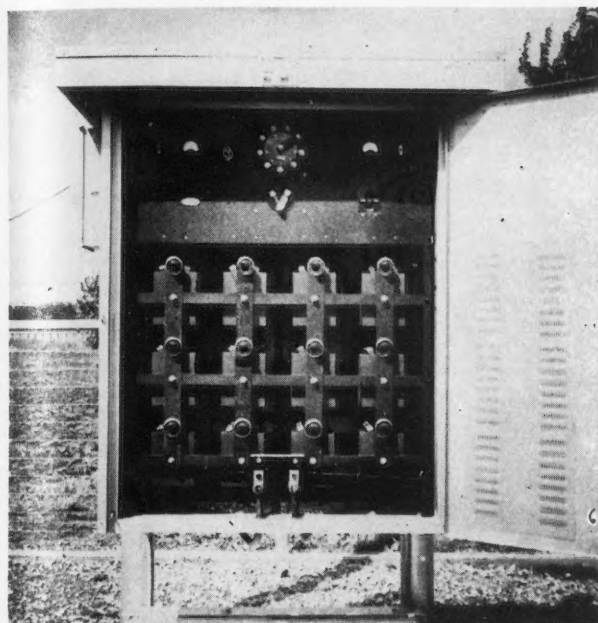
**Chase Condenser and Heat Exchanger Tubes for the Oil and Gasoline Refineries.** Chase Brass & Copper Co., 31 p. (1945) Dec. Gratis.

The behavior of condenser tubes in corrosive atmospheres is broadly discussed. Laboratory and field testing of materials for detecting corrosion are discussed. An outline of the different operations involved in the manufacturing of Chase Condenser Tubes is included together with extensive data.

**Corrosion Prevention in Processing Sour Crudes.** E. Q. CAMP. Humble Oil & Refining Co. Paper, National Association of Corrosion Engineers, Meeting, St. Louis, April 5-8, 1948; *Corrosion* 4, 371-98 (1948) Aug.

Some of the major corrosion problems experienced in processing sour crudes at Humble's Baytown Refinery and methods employed in mitigating these problems are discussed. Oxygen and water are accelerators of low temperature hydrogen sulfide corrosion. Carbonic acid, formed by carbon dioxide in distillation equipment causes appreciable corrosion at a pH of 6.0. Hydrochloric acid is found corrosive in distillation and cracking equipment. Tank corrosion is caused by action of hydrogen sulfide, oxygen, and water. Tank life is increased by heavier steel construction, roofs of aluminum and galvanized steel, caustic washing, protective coatings, gunite linings, etc. These protective media are applied to lines, distillation equipment, furnace tubes, condensers, cracking unit components, etc. Humble's experiences with corrosion in vapor-phase cracking are also discussed. Corrosion caused by naphtha, in this case, is reduced by addition of free sulfur, butyl mercaptans, carbon disulfide, or distilled water to the naphtha. Carbon

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dioxide, ethyl alcohol, acetic acid, hydrogen sulfide and sulfur dioxide are inhibitors for controlling corrosion in butadiene plant. Twenty-nine references.

#### Internal Corrosion of Crude-Oil Tanks.

R. A. BRANNON, Humble Pipe Line Co. Preprint, API 28th Meeting, Chicago, Nov. 8, 1948, 4 p.

Most of the corrosion damage from sour crude oils occurs on tank bottoms where salt water settles, and in the vapor spaces where moisture condenses. Reasonably satisfactory protective coatings have been developed for tank bottoms in the form of bituminous coatings which usually are applied in the molten state. As a replacement for steel bottoms which have failed, new bottoms constructed of concrete are widely used. In the case of vapor-space corrosion, most protective

coatings have proved to be of doubtful value. Aluminum is being used as a substitute for steel in the construction of tank roofs and roof-supporting structures. Guniting coatings for tanks have been used to prevent this corrosion. These coatings can be applied to tank roofs, shells, and bottoms. Floating roofs are also used to reduce corrosion because they practically eliminate vapor spaces.

**Nickel Alloys in a Great Chemical Industry: The Petroleum Industry.** B. DE BORDE. (In French.) *R. Nickel*, 14, No. 3, 51-64 (1948).

B. discusses the corrosive media involved in the refining of petroleum and the resistance to these media of nickel, Monel, Monel K, Monel S, Inconel, Hastelloy A, Hastelloy B, and various nickel-containing steels. The corrosive media in-

clude sulphur compounds, hydrochloric acid, sulphuric acid, sodium hydroxide, hydrofluoric acid, phosphoric acid, and organic solvents; in some instances the media are at elevated temperatures. The use is described of these materials in the construction of tank linings, distillation towers, condensers, heat exchangers, tubes, pumps, compressors, valves, and other refining plant.—MA.

**Installation and Performance of Scale Traps in Sour Crude Service.** G. L. CRAIG, Interstate Oil Pipeline Co. Paper before Int. Pet. Cong. & NACE Mtg., Tulsa, Mar. 20, 1948. *Oil & Gas J.*, 47, No. 6, 92-94 (1948) June 10.

Scale traps protect pipe-line facilities, reduce hydrogen sulfide corrosion and contribute to reduction in pump maintenance.—INCO.

**Aluminum Oil Pipe-Lines.** *Chem. Age*, 58, No. 1489, 153 (1948).

Aluminum has been found satisfactory for this application. Editor's note. Difficulty is experienced in some crude lines.—MA.

**Sour Crudes—Equipment Protection.** E. Q. CAMP. *API Proc.*, 27, (111), 153-166; discussion, 166 (1947)

An account of some of the major problems experienced in refining sour crude oils. Among methods of dealing with corrosion is mentioned the use of aluminum and galvanized-steel roofs for storage tanks. Admiralty-metal condenser tubes are also referred to.—MA.

**Coke Removal by Steam.** G. W. ALEXANDER. *Petro. Ref.*, 27, No. 6, 91-93 (1948) June.

In method of coke removal by steam, air, and heat application, a lime solution is injected in the charge previous to entering the furnaces to protect the tube metal from sulfur in charge stacks.—INCO.

## SURFACE PREPARATION

**Shot Peening. Effect of Shot Type on Spring Fatigue Life, Why Peening Calls for Uniform Shot.** Based on articles by F. P. ZIMMERLI and JOHN STRAUB, respectively. *J. Soc. Automotive Engrs.*, 56, 36-39 (1948) Nov.

Original papers were presented at a recent meeting of the Shot Peening Division of the SAE Iron and Steel Technical Committee.—BLR.

**Physical Control of Polishing Materials.** S. HOWARD WITHEY. *Prod. Fin.*, 1, No. 3, 30-32+ (1948).

Suggested methods of internal check and accounting with reference to materials required for metal finishing are discussed.—MA.

**Westfälisch-Anhaltische Sprengstoff-Reinsdorf (Surface Protective Treatment Tests of Aircraft Components).** Board of Trade, Ger. Div. Docs. Unit F. D. 2417-46, 2p. (1948).

Titles are given of a heterogeneous collection of laboratory notes (68 in number) on investigations of adhesives and protective lacquers for aircraft components with particular reference to electrically conducting lacquers and coatings of conducting foils (gold leaf or leaf foil).—RPI.

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**The Sand-Blasting of Metal Surfaces.** FRITZ WEHRMANN. *Metalloberfläche*, 1, No. 3, 56-57 (1947).

A brief description is given of sand-blasting equipment. Such details as type of blower, nozzle size, and sand consumption are considered.—MA.

**The Action of "Chromic Acid" on Zinc Coatings.** D. J. SWAINE. *ASTM Bulletin*, 52 (1948) Oct.

Results of the action of hot chromic acid solution on electrolytic zinc, galvanized sheet, and galvanized wire are tabulated. Weight losses are small enough to warrant continued use of this reagent for the removal of corrosion products from galvanized articles.—BLR.

**Diphase Metal Cleaners; Relation of Emulsion Stability to Cleaning Efficiency.** IRVING REICH AND FOSTER DEE SNELL. *Ind. Eng. Chem.*, 40, 2333-2337 (1948) Dec.

Compares two classes of metal cleaners—the unstable emulsion type and the

stable type. Metal cleaning tests and number dispersion tests were performed. In both cases diphase cleaners were more effective than stable emulsion cleaners. Reason for this is explained.—BLR.

**"Aluglas" (and "Magneglas"):** the New Look for Light Alloys. *Prod. Fin.*, 1, No. 3, 14-20, 80 (1948).

An account of the "Aluglas" and "Magneglas" vitreous-enamel finishes for aluminum and magnesium alloys, respectively. The finishes are fired at 500°-550° C for 5-10 minutes, "Aluglas" being available in lead-bearing and lead-free forms and "Magneglas" in the lead-bearing form only. A complete range of colors is obtainable, and in many cases a single coat is adequate. The range of alloys suitable for finishing is limited, but "Aluglas" bonds satisfactorily to commercial-grade aluminum sheet and aluminum silicon castings, and "Magneglas" to D.T.D.A.M. 503 magnesium sheet alloys and the D.T.D. A8 and AZ91 castings alloys.—MA.

**Molten Salt Bath Descaling Process** Materially Reduces Production Time. S. G. OSBORNE AND H. R. SPENCE. *Steel*, 123, 106 (1948) Dec. 13.

Describes Hooker process; illustrates and diagrams the equipment. The mixture of fused salts has the ability to change surface scale and other impurities chemically, permitting their removal in dilute acid in 0.1-0.01% of the usual pickling time with no measurable effect on the underlying metal. Tells how existing baths may be converted; describes chemistry involved in the process itself and the quench. Versatility is emphasized.—BLR.

**Vergleichende Korrosionsversuche mit 10- und 20 min. Lang MBV Ten Rein-aluminiumproben.** (Comparative Corrosion Tests on Pure Aluminum Samples Treated for 19 or 20 minutes According to the MBV Process.) RESCHKE AND GEIER, Vereinigte Aluminium-Werke A.G., Lautawerk, Ger., Office of Technical Services, PB-70191, Frames 3135-3140.

Visual examinations and weight-change measurements on pure hard rolled aluminum sheets which had been exposed to various corrosive media showed that protective coatings produced by a 10-minute MBV treatment may be superior to those produced by a 20-minute treatment.

Experimental treatments were carried out on hard-rolled sheets in a 6% MBV-salt solution containing 5 parts sodium carbonate to 1.5 parts sodium chromate at a temperature of 95-98° C. Surfaces treated for 20 minutes were darker in appearance than those treated for 10 minutes. All samples were next treated for 10 minutes in distilled water or in a water-glass solution and then exposed for 10, 20, and 30 days to a stirred 3% sodium chloride solution containing 0.1% hydrogen peroxide, to a spraying mist of 3% sodium chloride, and to a 2% copper sulfate solution. Weight losses in the stirring test and spraying mist were insignificant and somewhat greater for the samples which were treated for the longer period. Losses in all samples after 20 days were in general smaller than after 10 days. After the 30-day exposure to copper sulfate the sheets that had been treated for 10 minutes were less corroded than those which had the longer treatment.—DPA.

**U. S. Practice in Pickling Steel.** A. MANGIN. *Chimie & Industrie*, 60, No. 4, 331-5 (1948).

A description of descaling and pickling

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practice in 1945 in the U.S.A. Semi-continuous and continuous processes are used with speeds of 60-250 yards per minute. Mechanical descaling is followed by acid bath treatments. The effect of concentration of the acids, the temperature of treatment and ferrous sulfate are illustrated. The control of the bath solutions and the composition of a number of typical pickles is given. The spent acid is usually treated as waste. The newer sodium hydride treatment is at present in very limited use.—RPI.

**The Surface Protection and Finishing of Magnesium Alloys.** W. S. LOOSE. *Metals Handbook*, (ASM) 991-994 (1948).

L. describes mechanical and chemical methods of cleaning and chemical and electro-chemical (acid and caustic anodizing) processes of finishing. Painting is dealt with, but electroplating on magnesium is said not to be commercially practicable.—MA.

**STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912, AS AMENDED BY THE ACTS OF MARCH 3, 1933 AND JULY 2, 1946 OF CONGRESS, PUBLISHED MONTHLY AT HOUSTON, TEXAS, FOR OCTOBER 1, 1949.**

COUNTY OF HARRIS

Before me, a Notary Public in and for the State and county aforesaid, personally appeared A. B. Campbell, who, having been duly sworn according to law, deposes and says that he is the business mgr. of the Corrosion and that the following is to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily, weekly, semi-weekly or tri-weekly newspaper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the act of August 24, 1912, as amended by the acts of March 3, 1933, and July 2, 1946 (section 537, Postal Laws and Regulations), printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, National Ass'n of Corrosion Engineers 919 Milam Bldg., Houston, Texas.

Editor, Dr. Ivy M. Parker, P. O. Box 423, Bremen, Georgia.

Managing editor, N. E. Hamner, 919 Milam Bldg., Houston, Texas.

Business mgr., A. B. Campbell, 919 Milam Bldg., Houston, Texas.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one percent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.) The National Association of Corrosion Engineers, 919 Milam Bldg., Houston, Texas. A non-profit organization, therefore no stock issued.

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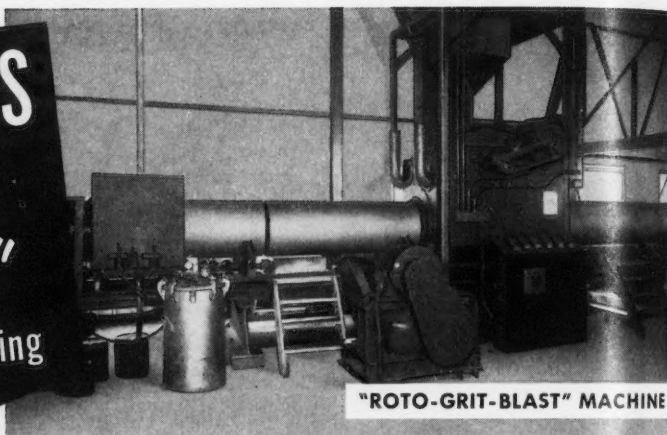
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Sworn to and subscribed before me this 21st day of October, 1949.

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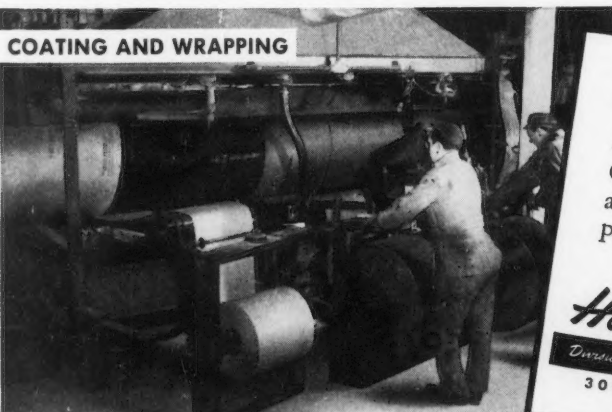
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